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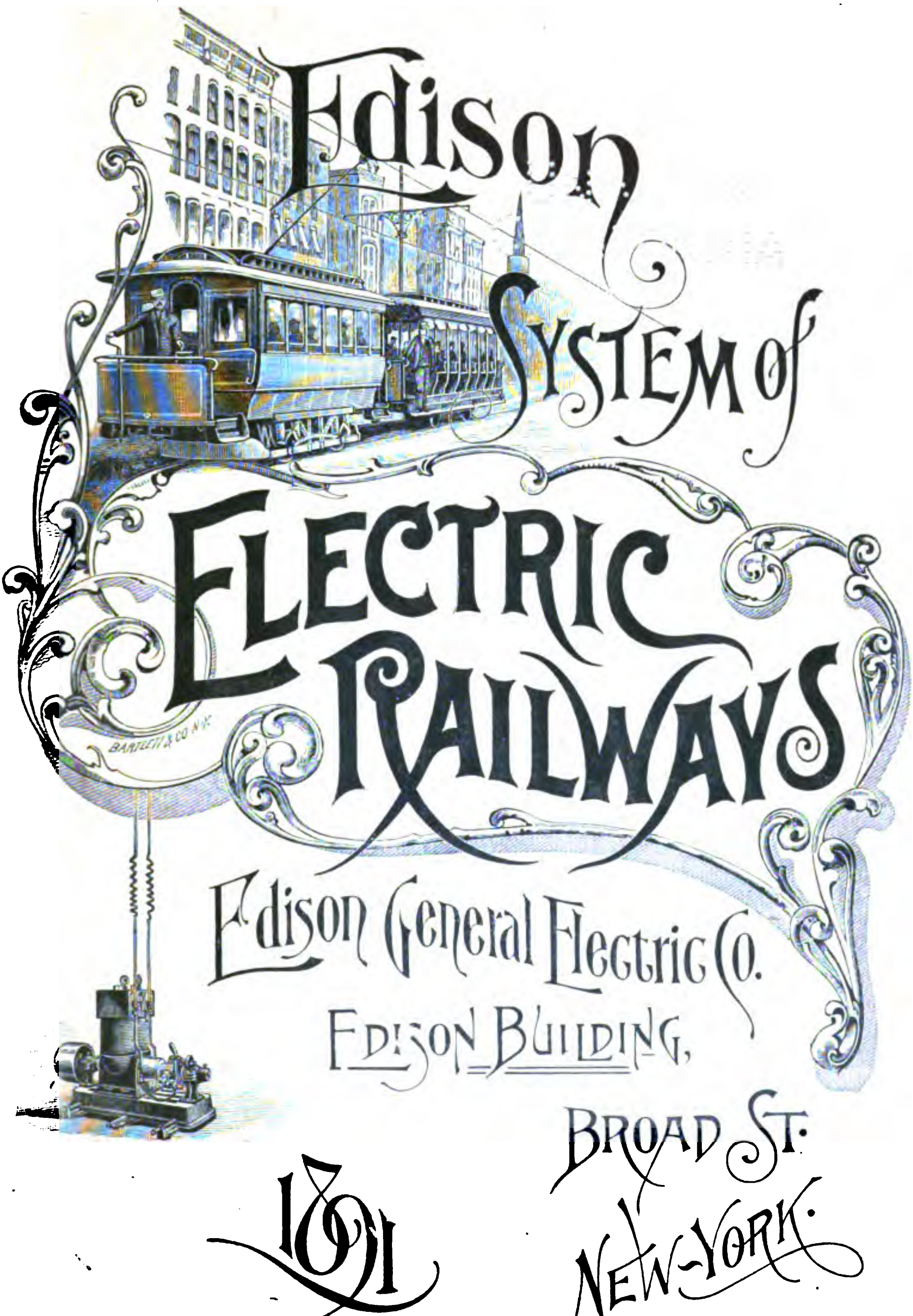
BARTLETT & CO N.Y.

Edison System of Electric Railways

Edison General Electric Co.

Edison Building,
Broad St.
New-York.

1891

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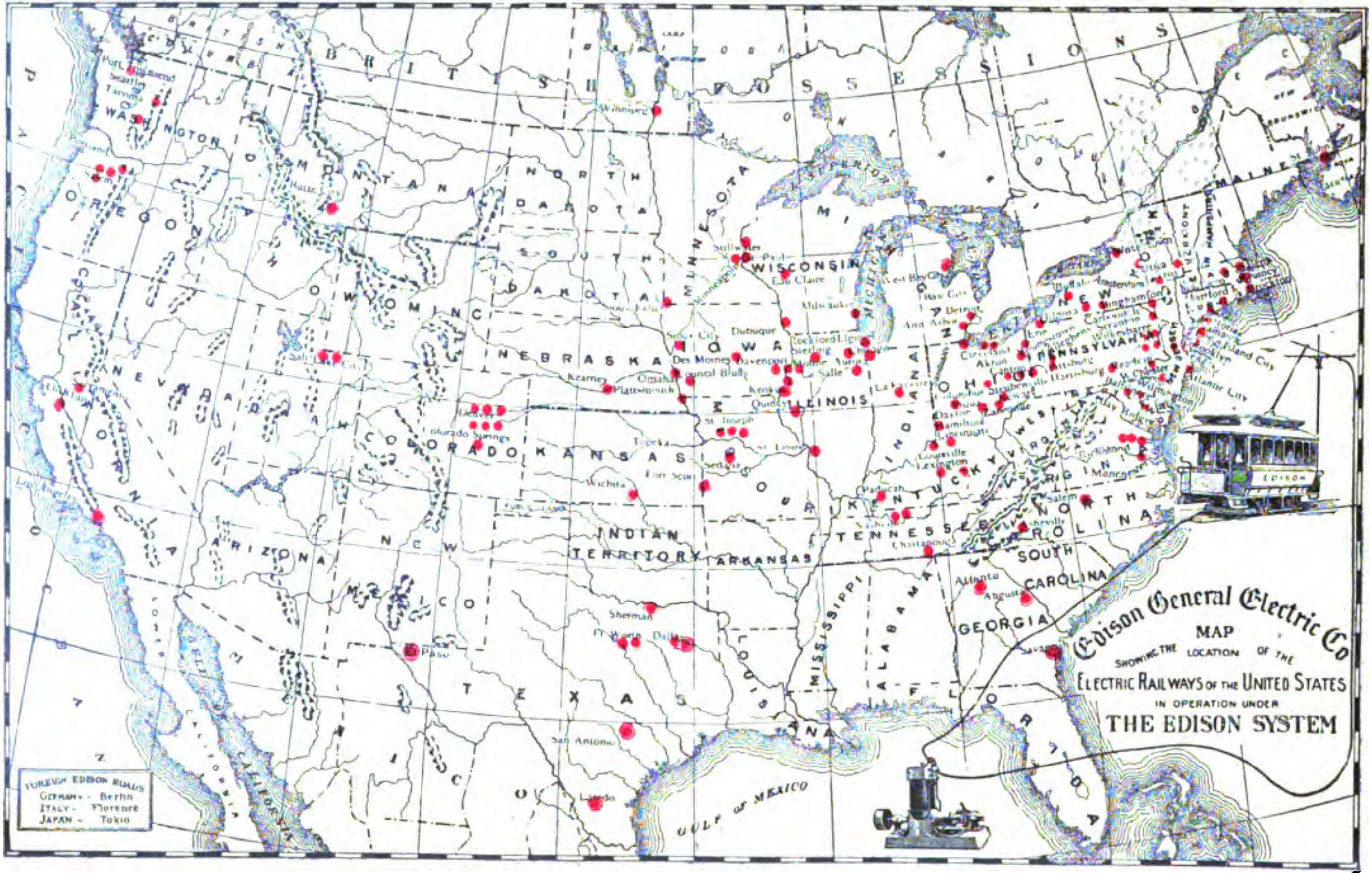
Edison General Electric Co
MAP
SHOWING THE LOCATION OF THE
ELECTRIC RAILWAYS OF THE UNITED STATES
IN OPERATION UNDER
THE EDISON SYSTEM
FOREIGN EDISON ROADS
GERMANY - Berlin
ITALY - Florence
JAPAN - Tokio
EDISON
BRITISH POSSESSIONS
PACIFIC OCEAN
GULF OF MEXICO
GULF OF CALIFORNIA
LOWER CALIFORNIA
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
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NORTH DAKOTA
SOUTH DAKOTA
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NORTH CAROLINA
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WEST VIRGINIA
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NEW YORK
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NEW HAMPSHIRE
MAINE
NEW BRUNSWICK
Port Townsend
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Minneapolis
Eau Claire
Sioux Falls
Sioux City
Dubuque
Des Moines
Davenport
Council Bluffs
Omaha
Plattsmouth
Kearney
Denver
Colorado Springs
Topeka
Wichita
Fort Scott
Sedalia
St. Joseph
St. Louis
Keokuk
Quincy
Rockford
Sterling
Aurora
La Salle
Milwaukee
West Bay City
Bay City
Detroit
Ann Arbor
Lafayette
Dayton
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Cincinnati
Louisville
Lexington
Paducah
Chattanooga
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Salem
Atlanta
Augusta
Savannah
Sherman
Ft. Worth
Dallas
El Paso
San Antonio
Laredo
Cleveland
Akron
Canton
Erie
Pittsburgh
Harrisburg
Reading
Wilmington
Baltimore
Richmond
Manchester
Buffalo
Binghamton
Utica
Carbondale
Scranton
Wilkesbarre
Hartford
Quincy
Brockton
Brooklyn
Long Island City
Atlantic City
Watertown
St. John

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EDISON SYSTEM

OF

ELECTRIC RAILWAYS.

Edison General Electric Co.,

Edison Building,

BROAD STREET, NEW YORK.

MAY, 1891.

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The Edison Overhead System for Electric Railway Work.

The overhead trolley wire for the conveyance of the energy of the dynamos to the motors upon the cars of street railways is the only method yet devised which is thoroughly satisfactory.

Underground conduits for the bare wire or working conductor, though put in without regard to cost, and given every opportunity for success, when practically operated and subjected to rain, snow, mud, ice and the accidents of everyday use, have in most instances proved to be failures. In Boston and other cities, where they have been installed on a large scale, their use has been abandoned for the present. The underground conduit with an open slot is necessarily more complicated and is liable to interruptions during heavy storms, owing to the difficulty of drainage.

The feeder wires or main conductors are now in many cases placed underground in waterproof insulated tubes, leaving only the trolley wire or working conductor suspended over the track. This construction is is now used by the Edison Company where objections are raised to the ordinary overhead methods, and has been in successful practical operation for a long time on several of the most extensive plants in the country.

The most economical and practical method of current distribution now in use, is the Single Trolley overhead system, and that system of overhead wiring for railway purposes, which is the least obtrusive, the lightest, and the least complicated, is the most desirable.

866770

The Feeder System.

The distribution circuit of the Edison System is the most simple, the most reliable and least unsightly of any yet devised, and has characteristics which are covered by fundamental Letters Patent.

It is practically impossible to distribute electricity over a large system and keep the pressure approximately constant at the various points of the line without using the feeder system, or a modification of it.

The cars can be run nearly as fast at the most distant points from the power station as they can close to it. With the feeder system the cars can be operated satisfactorily with a smaller loss of power on the line than where the trolley wire is the only conductor.

The overhead work is divided into sections so that if an accident occurs only the cars on the section affected are stopped. The heavy grades or curves of the line are reinforced by feeders so that the motors obtain the power neccessary to perform the extra duty required of them at such points.

It is a well known fact that by the Edison System cars can be operated with a much less expenditure of electrical power than by any other system. This means a saving of fuel, and a reduction in the size and cost of the power plant. In other words, the cost of operation per passenger carried or per car mile operated will be less, and the the fixed charges for interest, etc., dependent upon the capital invested will also be reduced.

Overhead and Ground Circuits.

In the Edison System the electric circuit consists of two parts, the overhead and the ground circuit.

In providing for the return of the current, the rails are grounded and form one side of the circuit. They are tied together by iron wires riveted to each rail end and properly connected.

The other side of the circuit consists, in part, of a hard drawn silicon bronze wire of small size but great tensile strength, which is suspended from seventeen to twenty feet above the track.

This trolley wire, or working conductor, is carried over the centre of the track by span wires running from pole to pole across the street, or by brackets attached to poles set on one side only. When the streets are broad and double tracks are used, the poles may be set between the tracks with bracket arms extending on both sides. No change in the size of the trolley wire is required with increase in the number of cars, or an extension of the line.

The size of the trolley wire is entirely independent of the number of cars to be operated or the length of the line, since the main portion of the current is carried in a main line wire or conductor running parallel to it, and connected to it at intervals of 400 to 500 feet by sub feed-in wires.

This main wire is of a size sufficient to carry the current necessary to operate all the cars over the entire length of line, up all the grades, with the maximum number of passengers, and is itself supplied, at suitable points, by reinforcing feed wires connected directly with the station.

Reliability of Service.

By the use of parallel conductors, and by means of special cutouts for line sections, the power can (even in case of an accident to the line) always be furnished to the cars, except immediately at the point of breakage.

Light Overhead Supporting Wires Possible.

The main conductor wire being carried upon the poles themselves, the span wires are not subjected to the enormous strain which is inevitable when the current is carried solely in the working conductor or trolley wire, because of the large size of wire necessary in that case.

System of Cutouts for Lines Sections.

In any system of distribution safety devices are interposed between the dynamos and the outside circuit, as a protection from injury due to a sudden overload caused by accidents to the line.

In addition to these main cutouts or safety devices the overhead work of the Edison System has cutouts interposed at the intersection of every lateral or subfeeder with the main feeder, thereby furnishing additional protection to the station equipment as well as to the line. Fusible cutouts are also inserted at each end of every reinforcing feeder from the station.

POWER GENERATION.

The marked favor in which the Edison generator is held is sufficient guarantee of their electrical and mechanical construction. They are economical in floor space, and the centre of gravity of the moving parts being low, insures perfect freedom from vibration. Their commercial efficiency is over 90 per cent.

The self-oiling bearings run practically without attention, the oil requiring renewal only about once in six weeks.

A novel feature which has been introduced by the Edison Company into Power Station Equipment is the Controlling Table.

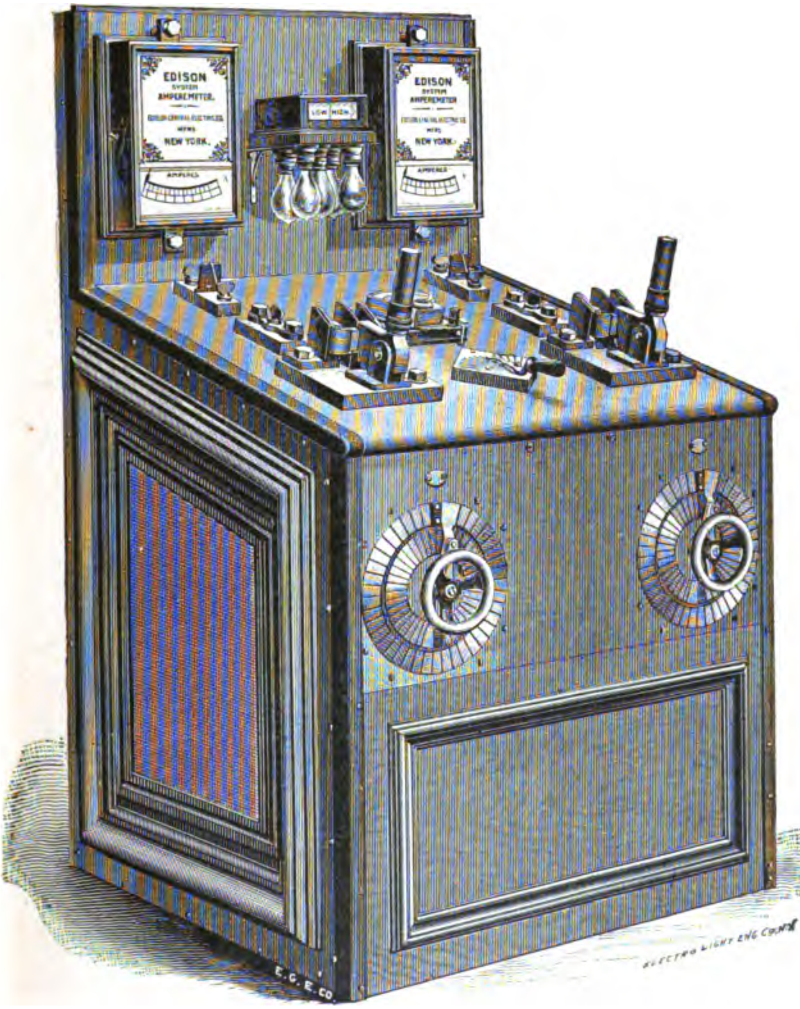
These tables are manufactured in sections, and have all the necessary Station instruments mounted compactly upon them. When any addition to the plant is desired, additional sections containing the necessary additional instruments can be supplied, which can be placed in position and connected up in a very few hours, thereby avoiding the delays caused by the additional wiring, and extension of the existing switchboard.

These tables are constructed of slate or other fireproof material.

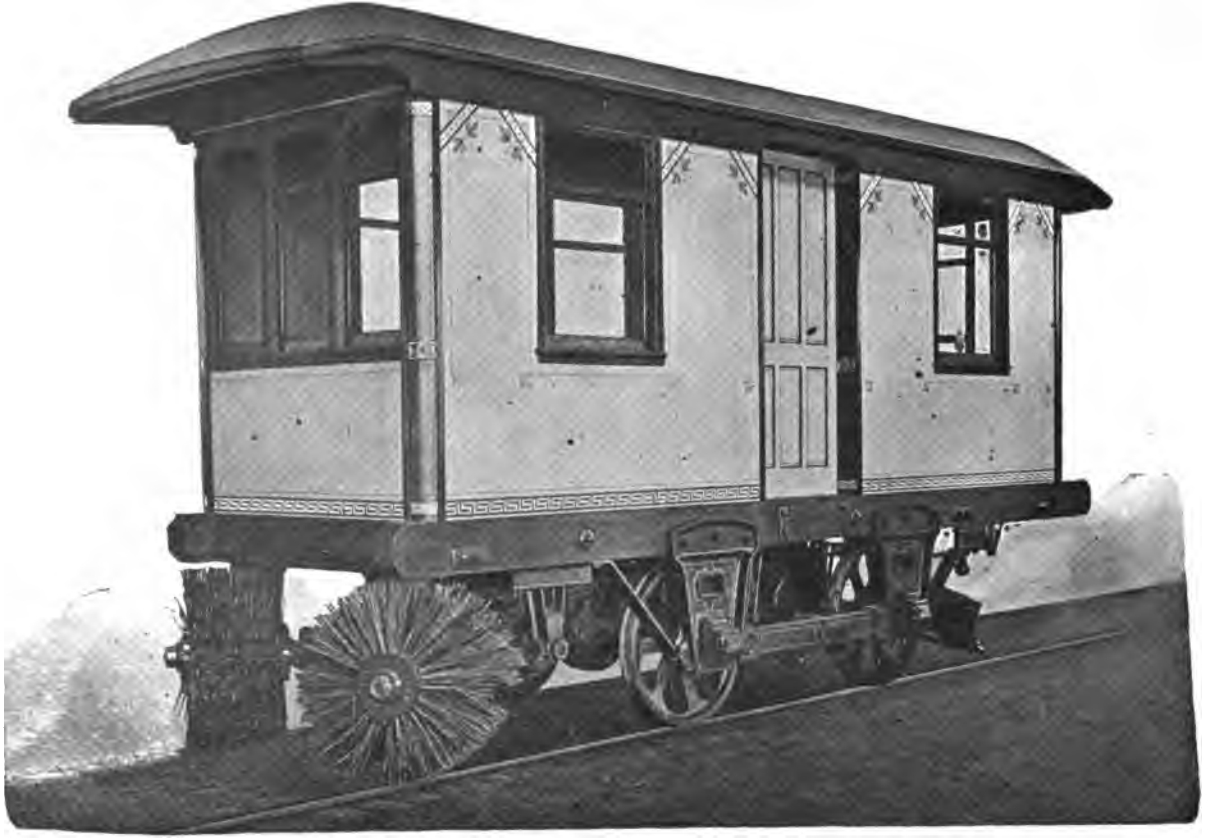
Sectional Feeder Boards with the necessary instruments are also supplied when required.

CAR EQUIPMENT.

In the Edison System the motors are supported and centered upon the axles at one end and carried by flexible support or suspension springs at the other, thus relieving the motor from sudden jars or strains in starting or reversing of the motor.



EDISON CONTROLLING TABLE FOR ELECTRIC RAILWAY POWER STATIONS.



EDISON SNOW PLOW AND SWEEPER.

The speed of the motor is governed by a peculiar controlling switch, which, by varying the position of the lever, changes the relations between the armature and field coils so that their electrical combinations are altered, thereby varying the speed, without the use of external resistances.

Both motors are simultaneously controlled from either end of the car, by a single movement of the switch lever, making the handling of the cars extremely simple; the driver or motor man requires little more instruction than is necessary when learning to drive a horse car.

The field coils of the motor are wound on separate spools of insulating material, which spools can be readily replaced if necessary.

The armatures are wound with the greatest care, several weeks being required to complete them.

In case of accident or danger to human life the motors can be **instantly** reversed, whereas in other systems two or three distinct operations are necessary before a car can be stopped and the motors reversed, thereby increasing the risk of accident.

Our double equipments are fitted with a cutout switch by which the man in charge of the car can cut out either one of the motors in case it is disabled and thus enable the car to complete the trip with the other motor.

Snow.

In case of heavy snow storms trouble may be avoided by the use of a properly constructed snow plow, propelled by two 15 H. P. or larger motors, and having sweepers operated by an additional motor properly connected to them, the whole of the machinery being easily handled and under the direct control of the man in charge. A cut of the Edison snow plow will be found on the opposite page.

LINE CONSTRUCTION.

Much time and study have been spent in obtaining the lightest, strongest and least unsightly overhead construction possible, and the line appliances and material for construction now used by the Edison Company give a structure at once simple, reliable and elegant.

The small size of the silicon bronze wire suspended over the track reduces the breakage of span wires and the sagging of the poles, to minimum. The use of feeders and cutouts prevent the accidental breakage of a trolley wire from stopping the whole system.

Guard Wires.

To avoid accidents and burnouts caused by broken telephone, telegraph and electric light wires falling across the bare trolley wire, guard wires are erected above the latter wherever necessary, thus preventing vexatious delays and costly repairs.

The foregoing statements are borne out by the successful operation of roads equipped with the Edison System in all parts of the country, and in many instances the satisfaction of the local companies is shown in a practical manner by a second, third, and sometimes a fourth order for additional equipment.

THE EDISON 25 H. P. SINGLE REDUCTION STREET CAR MOTOR.

Although the application of the high speed electric motor conveying power to the car axle by a double reduction gear has demonstrated beyond question the practicability and economy of electric railroading, it has become evident that improvement could be effected by the elimination of some of the gearing heretofore employed. The modification necessary to accomplish this purpose, readily suggests itself in the reduction of the initial speed of the motor and the employment of a single reduction only between the motor and the car axle. As the power of the motor is the product of the

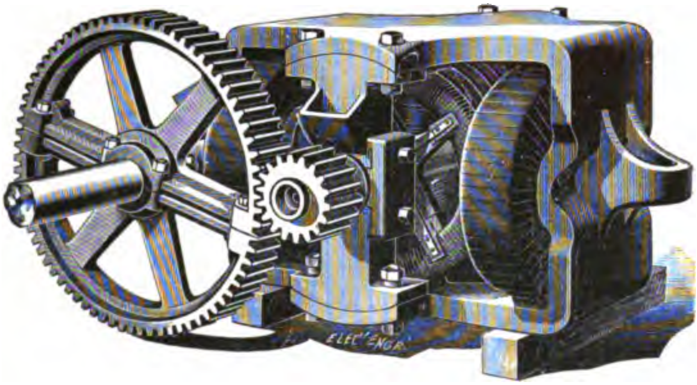


Fig. 1.

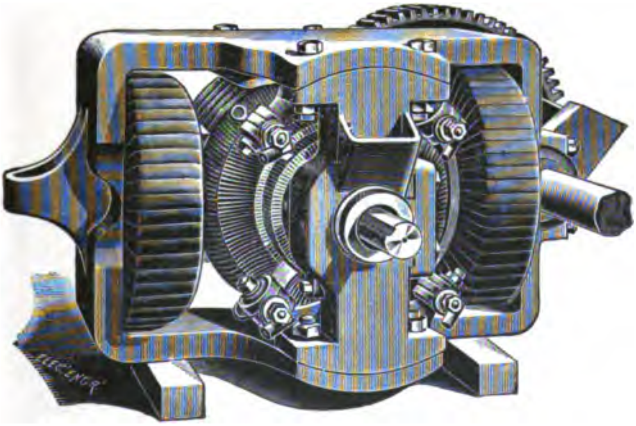


Fig. 2.

EDISON SINGLE REDUCTION STREET CAR MOTOR.

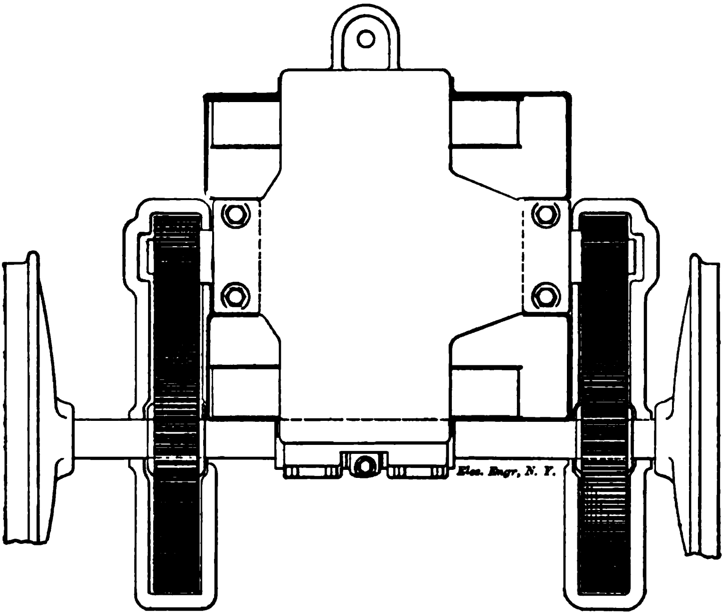


FIG. 3.

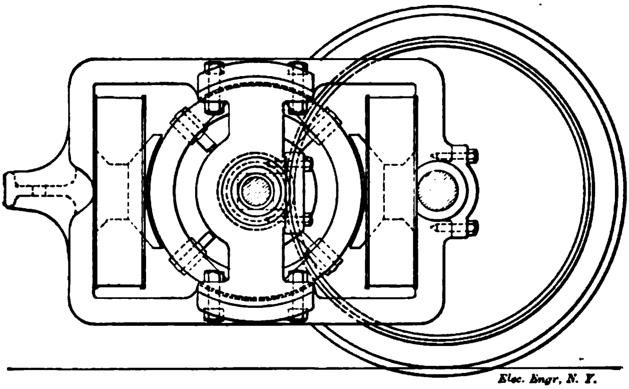


FIG. 4.

EDISON SINGLE REDUCTION STREET CAR MOTOR.

torque into the speed, the application of the slow speed motor necessitates a construction such that the torque of the motor shall be increased in the same proportion as its speed is reduced. This is best carried out in the multipolar machine, and in keeping with the progress going on in their other departments, the Edison General Electric Company are now building a type of single reduction street car motor which embodies several novel features.

In our illustrations of this machine, Figs. 1 and 2, the motor is shown in perspective as seen from either end of the armature, the gears being removed from the shaft in Fig. 2 in order to expose the commutator and brush arrangement. The more detailed construction of the motor is shown in Figs. 3 and 4, from which it will be seen that the machine is of the four-pole type and practically ironclad. Only two poles, those in the horizontal plane, are wound, the two in the vertical plane being magnetized by induction from the same spools and forming, as it were, consequent poles of opposite polarity. The entire field, consisting of special soft cast-steel, is made in one casting with the exception of the pole pieces which are attached by screw bolts after the spools have been slipped on over the straight cores at the sides. These pole pieces, it will be noted, extend for a short distance beyond the field coils, and practically 80 per cent. of the whole spool is surrounded by iron. As a result of this construction and the employment of cast-steel, the magnetizing force required to attain the proper degree of magnetization is small, and from the nature of the construction there is little magnetism which is not utilized.

The magnetizing coils are wound in three sections on vulcabeston spools, which, as stated above, are slipped on over the cores. In the construction of the machine the facing of the armature bearing and the cylindrical armature space are bored out at one boring, and by loosening two bolts the armature can be slipped out completely, so that inspection can be effected with great facility. The armature, which is of the Gramme type, is built up of punched soft iron rings insulated

16

from each other, and with the end plates of wrought iron and bevelled. On the interior diameter of the hollow cylinder built up in this manner, there are four grooves placed 90° from each other, and into these grooves the aluminum-bronze spiders are pressed by hydraulic pressure, two spiders being employed and bolted together. In this way a firm mechanical connection is made between the armature shaft and the ring.

The diameter of the armature is 18 inches, and its length 13 inches. The shaft is 3 inches in diameter, and upon each end is mounted a pinion which meshes with the large gears at each end of the axle, thus equalizing the power on the axle. One end of the magnet forms the car axle bearing and the other is suspended by a spring at the nozzle for easy starting. The commutator has been made specially large, being 10 inches in diameter.

The armature is wound in 140 sections, and on account of the strong field employed, and the method of connection to the commutator, no spark is observed. The winding is put on in one continuous length of wire, and at each section a tap wire of German silver is taken to the commutator. The object of employing a German silver wire will become obvious when it is pointed out that, as is well known, the brush in passing from one commutator segment to another short-circuits the coil between them for an instant. The introduction of the German silver wire with its increased resistance reduces the current induced by the short circuit considerably, and, hence, the sparking due to that cause; and it also aids materially in cutting down the current, it by any accident the motor should be accidentally short circuited. It will be evident, however, that in the operation of the machine only those two German silver wires are in circuit which lead from the commutator segments immediately under the brushes, all the others being, of course, without current during the period between their travel from one brush to the other; hence, although the introduction of these two short lengths of German silver wire has no appreciable effect upon the normal operation of the armature it affords a simple method of avoiding sparking and danger from short circuits. The entire machine is encased in a water-tight cover, and its total weight with gears is about 2,200 pounds. The machine is rated at 25 H. P., but will readily develop 30 H. P. It is intended to apply two of these machines to each car of the double truck type, while one machine alone will be ample to drive the smaller cars. The motor is of the series type and the regulation is effected by varying the combination of the fields, which are wound in three sections. By this method of regulation the use of a rheostat is avoided.

Four carbon brushes are employed, and the brush holders being rigidly fastened to the frame, require no shifting throughout the range of load to which the motor is subjected. The motor is calculatedto revolve at 460 revolutions with the car running at a speed of 12 miles an hour.

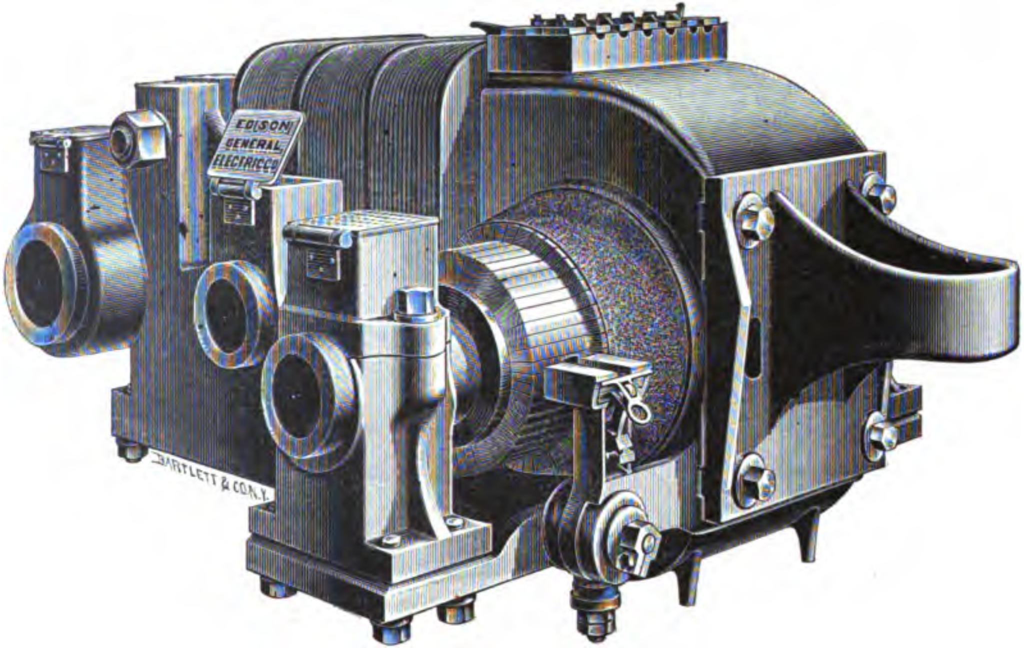
THE EDISON 15 H. P. SINGLE REDUCTION MOTOR.

A 15 H. P. single reduction iron clad motor of the same type and construction is manufactured by the Edison Company for use on level roads or light track where smaller machines are required at a lower cost.

15 H. P. DOUBLE REDUCTION MOTORS FOR STREET RAILWAY WORK.

The Edison Company now manufacture a new type of 15 H. P. Double Reduction Motor, designated No. 8, which is much stronger and stiffer than the older machines.

This motor also contains several improvements, is very compact in construction, and will operate easily on narrow guage roads. It has a better form of armature bearings, superior arrangement of lubricating appliances, a stronger and simpler method of attaching the brush holders, a larger and improved commutator, and is used two motors to a car, connected in series, thus dividing the load equally between the two motors, and is, without the complication of equalizing coils, equal in every respect to the No. 6 in all ordinary duties required in operating standard street cars.



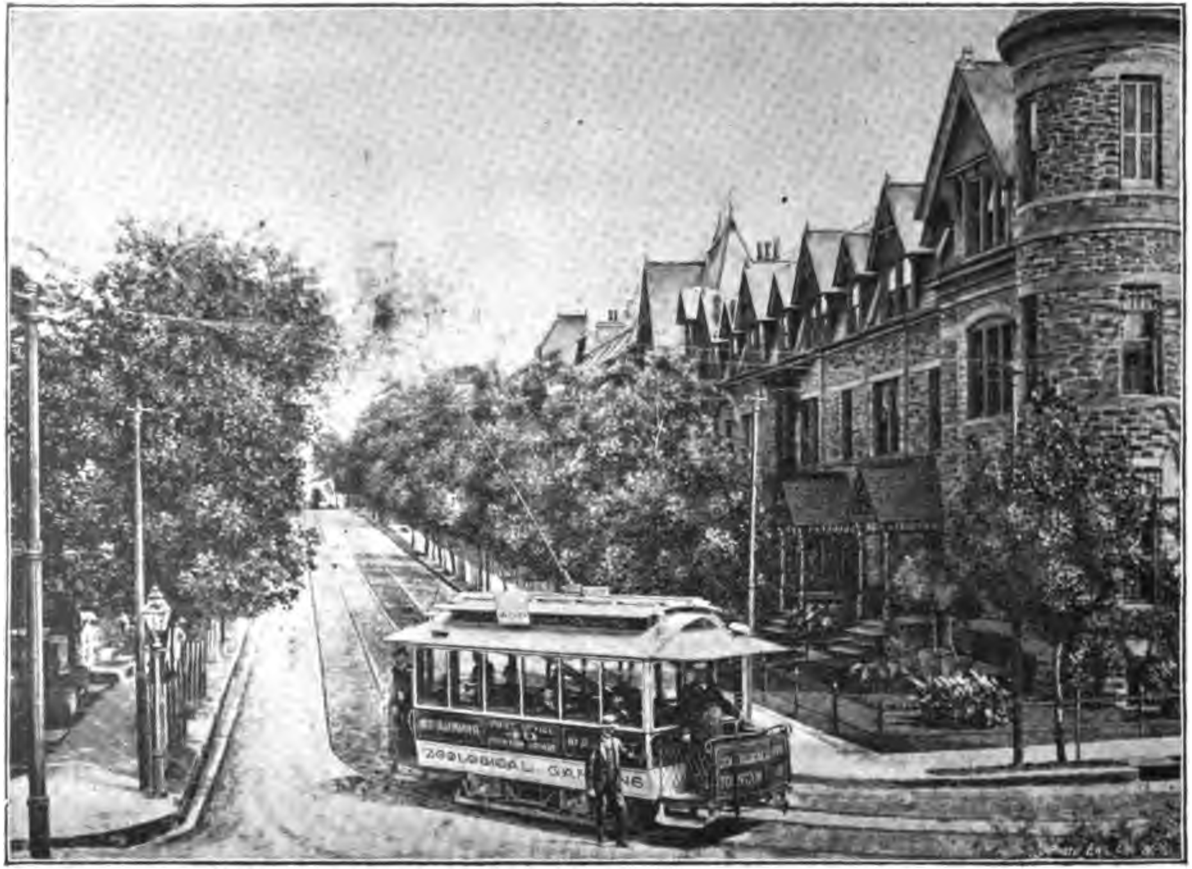
EDISON (No. 8) 15 H. P. DOUBLE REDUCTION STREET CAR MOTOR.

With the No. 8 motor a car can be operated at the slowest possible movement for starting, and up to a maximum of 9 to 15 miles per hour, according to ratio of gearing employed.

The motors being operated in series, the work is exactly equalized between the two motors; and each motor being under only 250 volts pressure, they are much less liable to electrical faults than other motors.

In practical work with over 200 motors they have proven to be thoroughly reliable, in fact, we have no reports of accidents to this machine.

Owing to the reduced voltage on the machines, possibility of accident is reduced to a minimum, and therefore the method described above commends itself to all practical men as the most economical and satisfactory.



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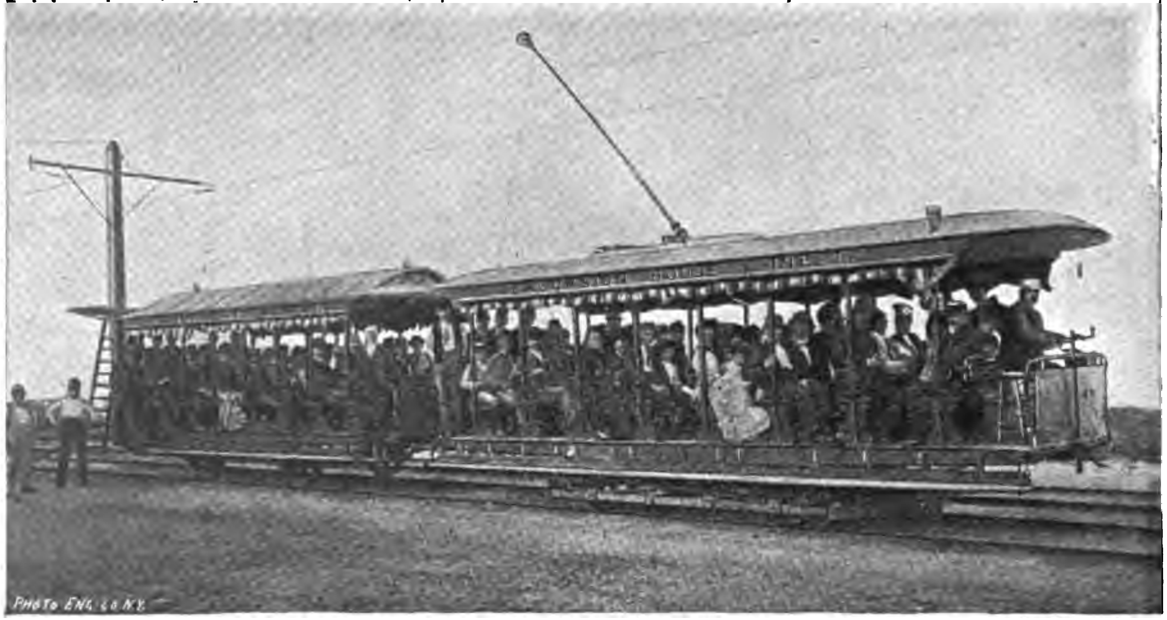
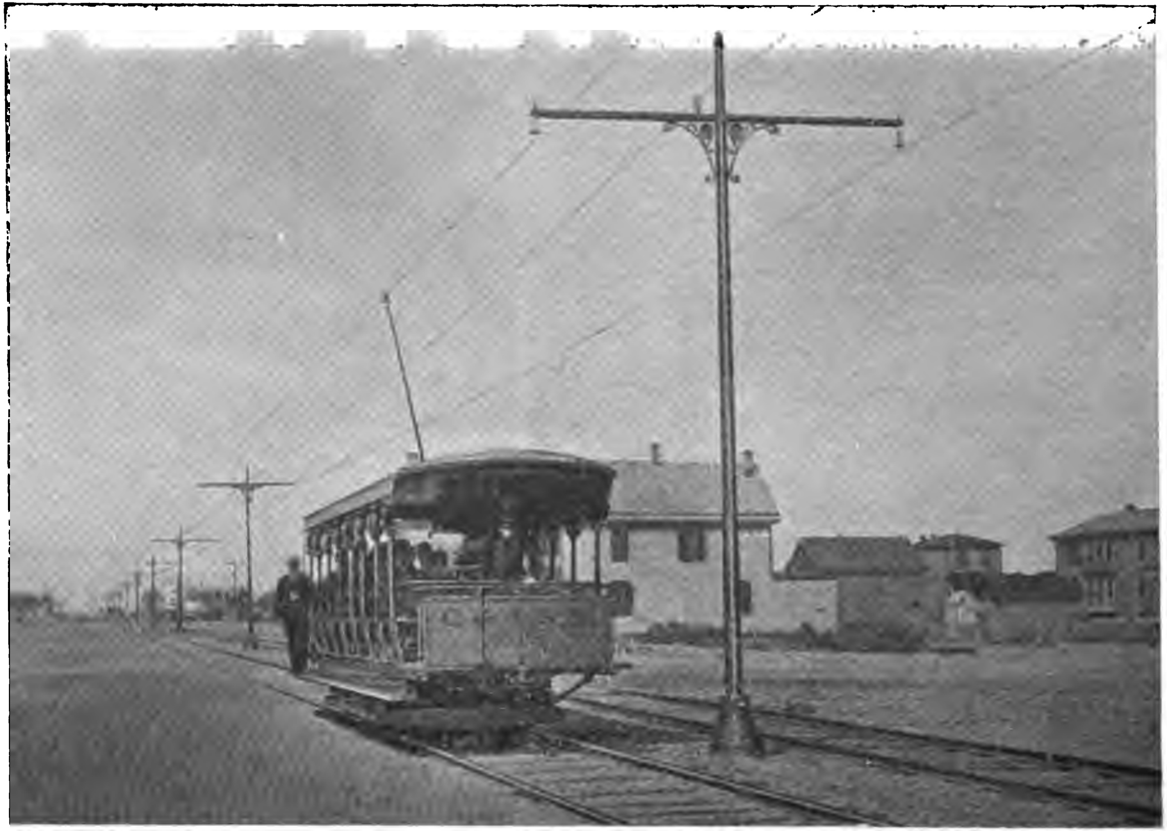


EDISON ELECTRIC RAILWAY, ATLANTIC CITY, N. J.



EDISON ELECTRIC RAILWAY, ATLANTIC CITY, N. J.

No. 12.

ADVANTAGES

OF A

Feeder and Sub-Feeder System

FOR

Electric Railways.

New York:
SPRAGUE ELECTRIC RAILWAY AND MOTOR CO.,
16 and 18 Broad Street.

THE SPRAGUE OVERHEAD SYSTEM.

AN overhead system of wires for the conveyance of the energy of the dynamos to the motors upon the cars of street railways is the only method, yet devised, which is at all satisfactory.

Underground conduits, though put in without regard to cost, and given every opportunity for success, when tested by rain, snow, mud and ice and by the accidents of every day use, have proved to be utter failures, and in Boston and other cities, where they have been installed on a large scale, their use has been abandoned.

The only practical method of current distribution now in use is the overhead system, and that system of overhead wiring for railway purposes which is the least obtrusive, the lightest and the least complicated, is the most desirable.

The distribution circuit of the Sprague system is the most simple, the most reliable and least obtrusive of any yet devised, *and has characteristics which it is impossible to duplicate without following the same methods and plans, which methods and plans are fully covered by a large number of fundamental Letters Patent owned by us.* WE ABSOLUTELY CONTROL THE MOST SERVICEABLE AND ECONOMIC METHODS OF CONVEYING THE ELECTRIC CURRENT TO THE CARS BY THE OVERHEAD SYSTEM.

One of the most essential features of the Sprague electric railway system, and one which goes far to produce its great superiority of economy, reliability, convenience and sightliness is the method of conveying the current from the main conductor to the trolley wire known as the *feed-in system.* This device is the envy of all competitors, and so universally are its merits acknowledged that railway companies contracting for the station and car equipments of other systems have desired their line work to be done in this manner.

OVERHEAD AND GROUND CIRCUITS.

IN the Sprague system the electric circuit consists of two parts, the overhead and the ground circuit.

In providing for the return of the current, the rails are grounded and form one side of the circuit. They are tied together by copper wires riveted to each rail end and properly connected.

The other side of the circuit consists, in part, of a hard drawn silicon-bronze wire of small size but great tensile strength, which is suspended from seventeen to twenty feet above the track.

This trolley line, or working conductor, is carried over the centre of the track upon span wires running from pole to pole across the street, or upon brackets attached to poles set on one side only. When the streets are broad and double tracks are used, the poles may be set between the tracks and have brackets on both sides. No change in the size of this trolley wire is required with increase in the number of cars, or an extension of the line.

The size of the trolley wire is entirely independent of the number of cars to be operated or the length of the line, since the main portion of the current is carried in a main line or conductor wire running parallel to it and connected to it at intervals of 400 to 500 feet by small lateral or sub-feeders.

This main wire is of a size sufficient to carry the current necessary to operate all the cars over the entire length of line, up all the grades, with the maximum number of passengers, and is *itself* supplied, at different points, by reinforcing feeder wires running directly out from the main supply at the station.

ABSOLUTE RELIABILITY OF SERVICE.

BY the use of parallel conductors, and by means of special cutouts for line sections, there is absolute certainty (even in case of an accident upon any portion of the line) of the current always being furnished to the cars, except immediately at the point of breakage.

LIGHT OVERHEAD SUPPORTING WIRES POSSIBLE.

THE main conductor wire being carried upon the poles themselves, the span wires are not subjected to the enormous strain which is inevitable when the current is carried solely in the WORKING CONDUCTOR or trolley wire.

SPRAGUE SYSTEM OF CUTOUTS FOR LINE SECTIONS.

THE main current wires, in any system, have fusible safety strips, interposed between the dynamos and the outside circuit, as a protection from injury by excess of current. All the current necessary for the successful propulsion of the cars must pass over these wires, which must of necessity be large enough to carry the current. It would require a complete "ground" to melt the safety strips of these mains and relieve the dynamos, otherwise slight crosses would be continually interfering with the system.

In addition to these main cutouts or safety strips, the overhead work of the Sprague system has safety strips interposed at the intersection of every lateral or sub-feeder with the main conductor wire, furnishing additional protection to the station equipment. The fusing of any one of these (of which there are ten or more to a mile) will relieve the pressure on the line.

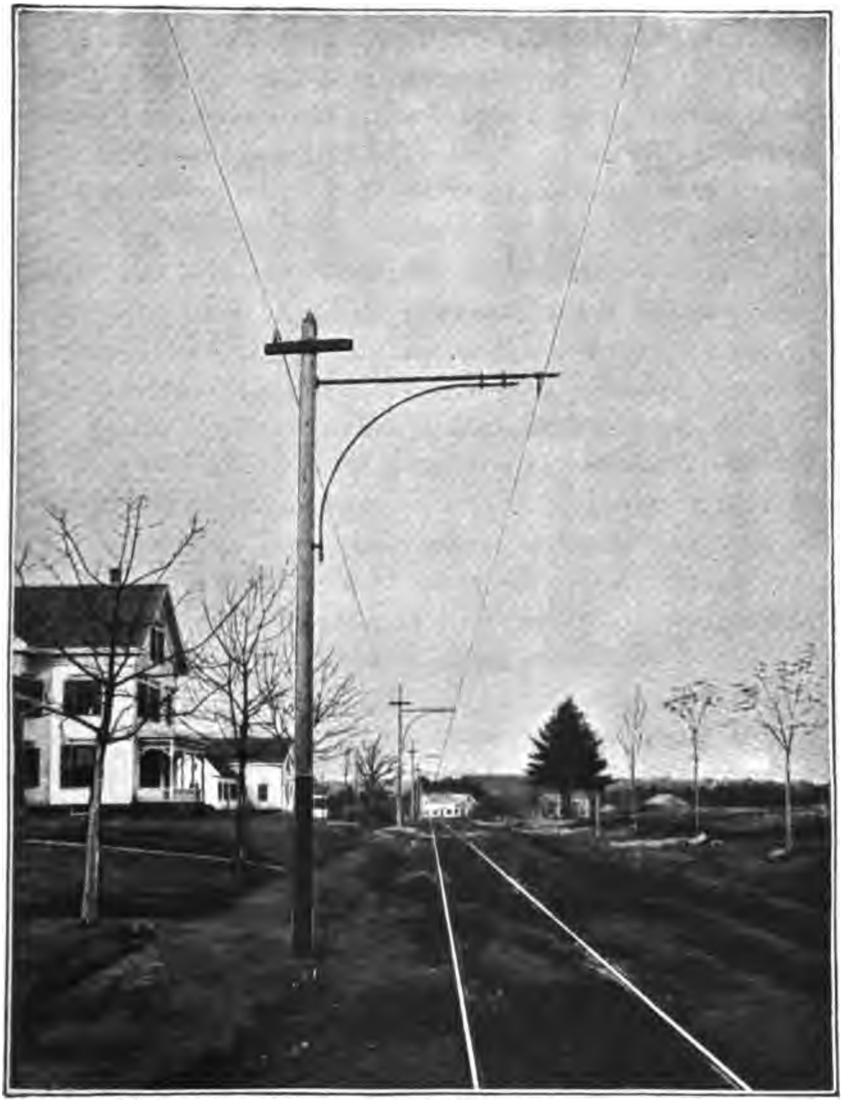
These IMPORTANT FEATURES *which are* ABSOLUTELY ESSENTIAL *to the operation of a street railway system of any size can* ONLY *be secured by the application of the Sprague system of line construction, which embodies the following principles:*

I. An independent trolley wire carrying current of equal pressure with the main conductor for immediate car service.

II. A parallel main conductor wire carrying the larger quantity of current over the entire system.

III. A system of sub-feeders or trolley line feeders giving very frequent supplies of current from the main line to the trolley wire.

IV. A system of principal feeders carrying current direct from the station to mathematically determined points of the main lines.



View Showing Single Bracket Construction.

TO illustrate the important advantages of this system, we invite your attention to the following diagrams:

Diagram No. I. shows the effect produced upon a series gas jets by the decreasing pressure in a pipe connected with of the main supply pipe at one end only. The friction or resistance to the flow increases in proportion to the distance from the gasometer and the illumination secured decreases correspondingly.

Diagram No. II. illustrates the trolley wire B of an electric railway system in which the energy is carried directly from the dynamos A A out over the line. As in the gas diagram the resistance to the passage of the current increases as the square of the distance from the dynamos A A, and as the voltage (energy or pressure) diminishes in proportion, it can be seen very plainly that the distance to which current can be economically carried to give good service is comparatively small, and that as the energy diminishes, so the power to propel the car diminishes, and the car speed decreases till a point is reached where the energy is insufficient for economical work, or for proper handling of traffic.

Diagram No. III. presents the effect upon a series of gas jets by a system of feeding the gas to them from various points along the main pipe, allowing the pressure at all points to be equalized, and resulting in lights of uniform power and brilliancy all along the line.

Diagram No. IV. illustrates an electric street railway system in which the current is carried to the cars over a trolley wire, B, which is fed from a main conductor wire, C, connected with the trolley wire at intervals by laterals or sub-feeders, D, which main conductor wire is also reinforced at proper points by auxiliary feeder wires, E, running directly out from the dynamos A A, to mathematically calculated points, F and G, to supply the energy necessary to keep the voltage (or pressure) up to that which is electrically, economically and commercially desirable.

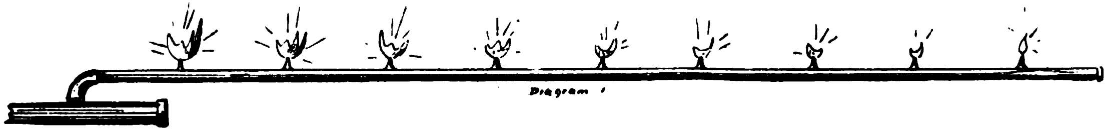


Diagram 1

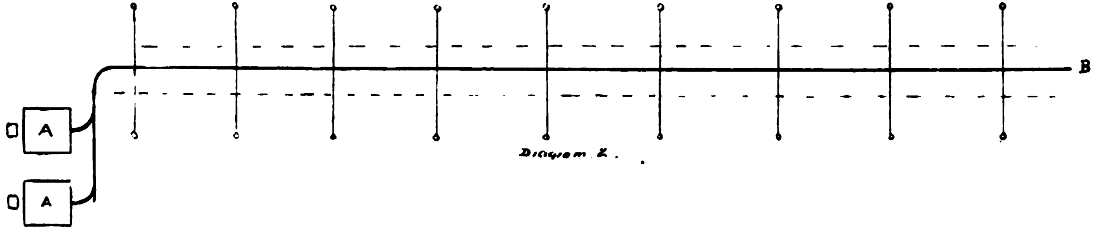


Diagram 2.

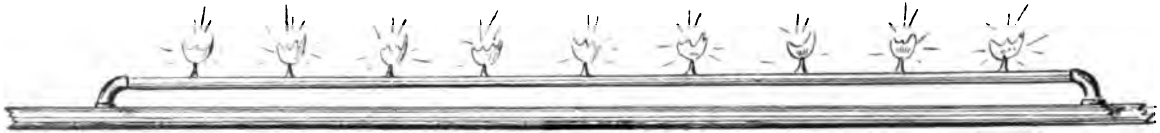


Diagram 3.

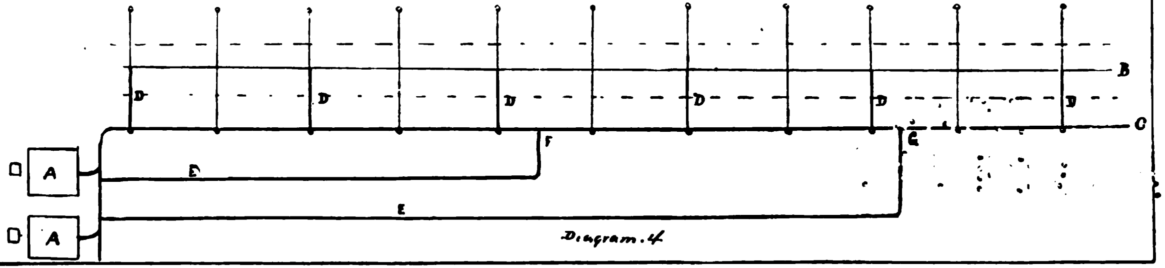


Diagram 4

OPINIONS OF STREET RAILWAY MEN IN REGARD TO THE FEEDER SYSTEM.

CERTAIN gentlemen interested in the street railways of San Francisco, Cal., desiring to know the estimate put upon this feed-in system by parties who have practically demonstrated its claims, addressed letters of inquiry to the various roads using the Sprague system, with the results appended.

We call your *earnest attention* to these letters, hoping at an early day to be permitted to demonstrate on your road the same results we have obtained elsewhere.

GENTLEMEN—In answer to your favor of 5th inst., will say that I am unable to answer your question at the present time. We are now equipping 5½ miles of double track with the Sprague system, and expect to begin operating the last of the month. We believe that the feed-in system has some advantages over the T. H., but have had no experience. Will know more in six months from now. Very respectfully,

W. A. SMITH,
Supt. Omaha Horse Ry., Omaha, Neb.

GENTLEMEN—Your favor of 5th inst. received, and in reply would state that our new electric system is not in operation yet, as we have been delayed by reason of laying new track. We think the feed-in system is one of the greatest advantages of the Sprague over other systems, and that was the chief reason that we preferred making our contract with the Sprague Co.

W. H. GRAHAM,
Sec'y Federal St. & Pleasant Val. Pass. Ry., Pittsburgh, Pa.

GENTLEMEN—We are operating in two cities with the Sprague overhead system with very satisfactory results.

Respectfully,

W. T. VAN BRUNT,
People's St. Ry., St. Joseph, Mo.

GENTLEMEN—Your letter of Sept. 5th to hand, and contents duly noted. In reply to your query, all we can say is, that we are putting in quite a line of road in the two cities here, but have not yet got to running; but from observation and investigation we found that the Sprague motor system is the system for street service, and have therefore adopted that.

Very respectfully,

W. J. WATSON,

Supt. Union St. Ry., Sterling, Ill.

GENTLEMEN—In answer to yours of 5th inst. respecting feed wire system, would say that it is the only way to operate a road. We have seven different branches here fed in this way, and each branch is separated from the other by a cutout, so that in case of trouble on any one line, the others can keep going. We tap on to the trolley wire about every eight poles.

Yours truly,

J. H. VANDERVEER,

Supt. People's St. Ry. Co., Scranton, Pa.

GENTLEMEN—Yours of 5th at hand. In reply would say that the "feed-in" system, as put in by the Sprague Electric Railway & Motor Co., was the principal feature that decided us to adopt the Sprague system. We have had practical demonstration of its value and utility several times. Once an arc wire fell across our trolley wire, and burnt it in two. We at once got the ends off the ground, and the road continued to run, delaying about fifteen minutes. Had we depended upon the trolley wire for our supply of current, we would have been delayed over an hour, if not more.

Yours truly,

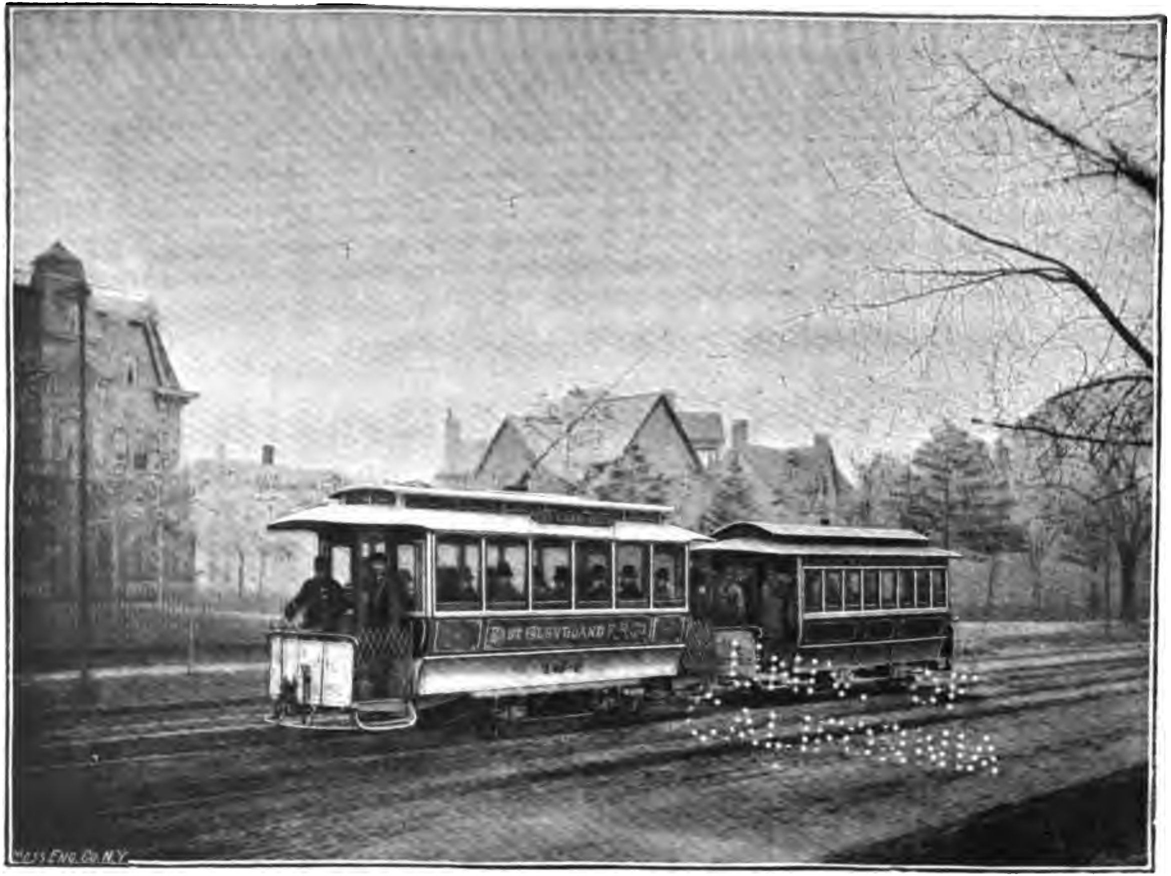
EAST CLEVELAND R. R. Co., by C. W. WASSON.

GENTLEMEN—Your favor of 5th inst. at hand, and contents noted. We have had a year's experience with the feed-in system in a way that we *know* its value. On an extension of our line we only fed in once, while on the balance of the road we used the regular "feed-in." We would *not* use any but the feed-in, in fact, the difference is much greater than we thought possible, and a month ago we had our lineman tap in the feed wires on that extension, since which we have been able to make from 6 to 8 miles an hour on it, and the grade runs from 4½ to 8 per cent.

Very truly yours,

R. J. HAWVER,

Supt. Lafayette St. Ry. Co., Lafayette, Ind.



VIEW SHOWING DOUBLE TRACK, SPAN WIRE CONSTRUCTION, MAIN CONDUCTOR BEING CARRIED ON POLES AT SIDE OF STREET.

UNIV. OF CALIFORNIA

GENTLEMEN—In reply to your favor of the 5th, we would say that we would build no overhead system for electric railways without a feed wire. The advantages are many, but the principal ones are: 1st, in case of breakage on lines; 2d, equality of power or current all over the lines, no matter how much is used by cars running very close together with load on at the extreme end of the line. Respectfully yours,

ERIE ELECTRIC MOTOR CO., *Erie, Pa.*

GENTLEMEN—Yours of September 5th at hand. I have been absent for the past week in Cincinnati, which is the reason you have not received a reply before. While I was there I saw the Daft and T.-H. systems, and rode on both roads, as I wanted to see if they had anything I could duplicate to use myself that was better than I had on the Sprague road here, but I found nothing, and came back satisfied with everything I have, and I have a Sprague system. It is far superior to the Daft or T.-H. in every respect; takes less fuel and power to run the same number of miles and costs less to put in.

Yours truly,

W. H. OBER,

Supt. Stillwater St. R. R., Stillwater, Minn.

GENTLEMEN—Yours of 5th inquiring our opinion of the feed-in system used by the Sprague Electric Railway & Motor Co. in their overhead system received. We have used it with great satisfaction for nearly three years. The following are the advantages which experience has shown us are clearly in favor of the feed-in system: First, a much lighter aerial construction; there being less weight in the trolley wires, the cross wires, and everything connected with the overhead system is much lighter. Second, the cars at a distance from the power station move more steadily than they would without the feed-in system. Third, in case of a break in the trolley wires made by a house moving, as once happened to us, you can operate your cars on both sides (or ends rather) of the break. Fourth, the main wire can be hung on poles in other streets or alleys, as our company has done, enabling the railway company, in case of a fire, to cut out parts of the line and operate the remainder. The writer has not used the other electric railway systems (without feed wires) but has observed them in different western cities. In every instance the trolley wire has been much more heavy than with us.

Very respectfully yours,

A. STEINACKER,

Sec'y Union Ry. Co., St. Joseph, Mo.

Gentlemen—Yours of 5th inst. received; would state that I have had more experience with the Sprague system of wiring than any other superintendent in the electric street railroad business, and I know its merits. First, it is the safest. Second, with the feed-in system it distributes the current equally over the line. Third, when the trolley wire is broken in half a dozen places the cars run just as if nothing has happened right up to the break next to the dynamo. In the other systems, all the cars on the side beyond the break next to the dynamo must stop, since the current cannot get to them. With the Sprague feed-in system there is current all the time in the trolley wire beyond the break and on the side next to the power station. Fourth, it prevents sudden strains on the dynamo. With other systems the car nearest the power house gets the most of the power, and the car at the other end of the line takes what is left. You know electricity always goes to the point nearest the ground, consequently the car nearest to the fountain head gets the big end of the cake. Fifth, it does not take so much engine power. I have seen several other systems, and in all cases for safety, neatness, durability and saving of expenses, I give the Sprague system the preference. Parties who may see this statement may say the writer is blowing up the Sprague system for his own advancement. I will say the Sprague Company individually is not friendly to me, neither am I to them, but right is right. I will take great pleasure in giving you any information that I have derived from my experience with the Sprague system, and it will be to the point. If any defects, I will name them. Hoping you will be successful with your roads and prove that this system is all O. K., I am,

Very respectfully,

A. G. DAVIDS,

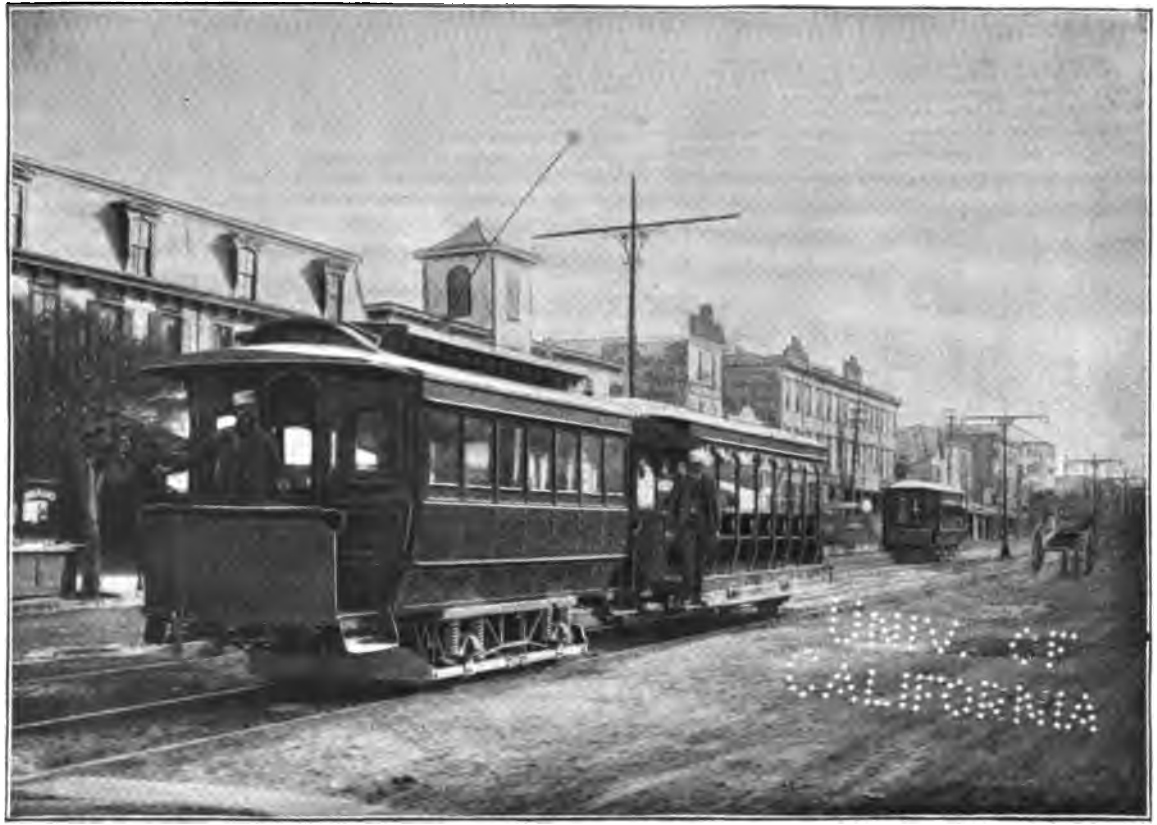
Supt. Steubenville St. Ry. Co., Steubenville, Ohio.

Gentlemen—In regard to the feed-in system of overhead wiring, it is undoubtedly the best yet put in use; it gives a constant potential at all points of the line and reduces the size of the working conductor. Also, should the working conductor break—a thing the writer has never seen in over two years' experience with electric street railways—it would allow of cars to be run to the exact point of the break and with sufficient headway pass that point. On one road the writer was connected with, which did not have feed-in wires, there was considerable diminution in the speed of cars at the end of lines.

Respectfully yours,

W. G. ROOT,

Supt. Eau Claire St. Ry. Co., Eau Claire, Wis.



UNIV. OF CALIFORNIA

View Showing Centre Pole, Double Bracket Construction.

UNIV. OF
CALIFORNIA

GENTLEMEN—Your favor of 26th ult. at hand. We are perfectly satisfied with the Sprague Electric Motor System, and within the past fortnight have ordered $82,000 worth of additional motors. Trusting that will show our satisfaction with them, I am,

Yours respectfully,

H. A. EVERETT,

Sec. & Treas. East Cleveland R. R. Co.

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No. 27.

ADDRESS

DELIVERED BY

HON. JOHN S. WISE,

OF THE NEW YORK BAR, AT

THE FOURTEENTH ANNUAL MEETING

OF THE

New York State Bar Association,

HELD AT

ALBANY, N. Y., JANUARY 20, 1891.

SUBJECT:

New Litigation in the Highways resulting from the use of Electricity.

ISSUED BY
EDISON GENERAL ELECTRIC COMPANY,
44 Broad St., New York.

No. 27.

Mr. President and Gentlemen :

One of the most marked changes which has taken place in our profession of late years is the rapid crystallization of our employments into specialties. The old county court lawyer, whose library was in his saddlebags, whose consultations were often on horseback, and whose cases embraced all classes of litigation, is a thing of the past. The volume of labor for the lawyer in any single department of business is such in our day that few of us have shoulders broad enough to bear the burden of more than one branch of knowledge and employment. The boast of the old-time lawyer was, that legal principles were immutable. The modern practitioner, without denying that utterance, recognizes that the application of legal principles to the novel business conditions, and changes of method, which are daily occurring before his eyes, forces the law to build such new supports to old foundations, and so to remodel its ancient structure, that even the temple of justice has a very modern aspect.

Within the last twenty-five years vast changes have taken place in almost every department of law. An intensely practical age, demanding results upon the merits, and scorning evasions upon quibbles, has swept away a great mass of legal tricks of special pleading, which at best were the offsprings of two centuries of pedantry. Men who were called great a half century ago for the nice discriminating power of their minds upon forms of procedure, would to-day be put aside as mere obstructionists in the way of decision upon the merits. The books they made lie dusty and useless on our shelves.

Around our National Constitution we have witnessed the sweep of a mighty storm, giving birth to new construction, until it is no great exaggeration to say that we find the great Marshall's opinions almost as often overruled as sustained.

On questions of State autonomy we have seen our people meet in bewildering shock from the confusion of which they have only been extricated at last by the wisdom and calm justice of the Supreme Court of the United States; which, while itself a creature of federal power, has proved to be the dispassionate expounder and conservator of true State's rights.

Statutory enactments, both State and Federal, have been made, which, while intrinsically right, would have astounded our earlier lawgivers, and which, in many instances, have set at naught their most labored utterances. Of this class, I may mention as a single instance the laws now almost universally enacted throughout the States of the Union, giving the latest employee of a railroad a lien for his wages superior to the oldest mortgage upon the road, and applying to railway employees the principles of seamen's wages, until a railway car has been aptly designated as, in contemplation of law, "a ship on wheels."

But wonderful changes in constitutional law, and methods of procedure in the courts, and in statutory enactments, are not the most surprising revolutions in the law which we have witnessed. Methods of business have changed more in thirty years than they did in two centuries preceding. Branches of industry discovered but yesterday have sprung up and grown with the rapidity of Jonah's gourd, until the capital employed in them mounts up to hundreds of millions; and, viewing our dependence upon them, the vast comfort and luxury which they furnish, the facilities for intercourse and for the transaction of business which they supply, the wonder is how we existed and transacted business before they were discovered.

Law may be truly said to be the aftermath of the crop of business. As in agriculture, the preceding crops, and fertilizers used, may be recognized by the character of their aftermath, so the class of litigation in our courts with equal certainty indicates the character of the business in which our people have lately been engaged.

Following in the train of all these new branches of business has come their aftermath of law filled with questions of novelty and difficulty. These last comers into the already crowded house, young and lusty, bold and aggressive, demand their share by the fireside, boldly grapple with the older occupants, unblushingly assert their contempt for the vested rights claimed by their predecessors, which, if allowed, would exclude them, and fill our courts with their clamor to have assigned to them a fair position in the business world. It would be impossible within the limits of this paper to discuss all the new enterprises which have arisen of late years and which fall within this general description. For this reason, and for the further reason that one is generally most interesting and always most intelligible upon the subjects which he has studied most thoroughly, I shall confine myself to the discussion of the new uses of public highways resulting of late years from electrical discoveries and the novel legal questions which have arisen from these uses.

Nothing, I venture to say, more aptly illustrates the changing character of the law, or its adaptability to the advancing steps of civilization, than a study of American decisions upon the uses of public highways. Turning to the decisions of a hundred years ago, and taking them from any State of the American Union, we find the language of the judges substantially identical, to the effect that the primary and dominant object in the dedication of a public highway, whether it was a road in the country or a street in the city, was for travel thereon, and the use thereof by the people, on foot, on horseback or in wheeled vehicles. At that time the proposition seemed very plain and very simple. The great systems of piping for sewage, for gas, and for water works, for heating and for other purposes, which are the products of the last

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century of civilization, without which, in our crowded communities, we would now be not only uncomfortable but diseased, were not only unnecessary but unknown. But time brought them. And when they came, with all their comforts and blessings, time brought also to the judges good reasons to qualify all expressions in former utterances which seemed to vest absolute and exclusive dominion of the highway in public travel alone.

Then came the era of steam railroads. The foot passenger, the man on horseback, the traveler by wheeled vehicles drawn by horses—all the old methods of travel by land were revolutionized; The iron horse was crowned king. The stage coach,—The chariot,—The bounding thoroughbred,—These, the pride and glory theretofore of travelers, passed, if not into the realm of innocuous desuetude, at least into a very subordinate use. With the introduction of railroads, came their demand for the occupancy of the public highways. The fact that the highways were naturally the best routes and that they had been already more or less graded and beaten down by travel, made their occupancy the object of most ardent desire by the projectors of railroads. The struggle for their possession by the railroads at once began and was continued for several years. It was urged that the railways were pre-eminently devoted to travel and transportation; that the method employed by them was infinitely superior to any other then known, and that the occupancy of the highway for such purpose was their undoubted right. But the argument against them was overwhelming. To grant them such occupancy, with such form of construction as they proposed, was equivalent to the exclusive grant of the highway to them; for it would be impossible without great danger to life and limb for pedestrians or horsemen or ordinary wheeled vehicles to occupy the same roadway with a railroad. Common sense governed the decisions. The railroad was excluded from the highway and forced to build and occupy its own route, leaving the highways to the ordinary uses of travel theretofore in vogue.*

But, again, in these decisions, not foreseeing what was to come in the developments of the future, we find the books filled with judicial expressions which were allowed to stand unmodified but a few years. When the railroads proposed to lay their tracks, bridging and cross-ties, on the public highway, judge after judge, in denying their demand, declared that the highway was dedicated to travel by the people on foot, on horseback, or in wheeled vehicles *not confined to a fixed track.* As the railroads fell within this last inhibition, their exclusion seemed easy upon that construction of the true nature of the uses to which the highways had been dedicated.

Yet it was but a little while before the horse car came into use. This was a new method of public transfer, popular with all classes of people. It was a wheeled vehicle; therein it was unobjectionable. It was propelled by horses. It was strictly in the line of travel suggested as an appropriate use of the highways by all former decisions. But it *was confined to a fixed track;* and therein the prior decisions were invoked to bar its occupancy of the highway. But the judicial mind of the period, then as now elastic, always responsive to the overwhelming demand of public sentiment, and always willing to construe away difficulties arising from the language employed in prior decisions, when the necessity arises, took but a little while to find the distinction upon which steam railways were excluded and horse railroads were admitted to the public highways. It was held that the language in the prior decisions relating to steam railroads forbidding all travel by fixed tracks was too broad, and should be considered as describing the heavy steam railway structures which make a highway difficult or impassable for wheeled vehicles, but not applicable to the inoffensive strap rail, flush with the surface of the highway, employed by the modest horse car.*

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* Pierce on Railroads, 234.
Mills on Eminent Domain, Sec. 205.
Angell on Highways, Sec. 91 *d*, n. T.
25 Amer. Law Reg. N. S., 431; and cases cited.

Thus, one by one, we see the new intruders on what wasonce exclusive ground taking their places on the public highway with their rights and relations to the older occupants adjusted by the courts.

We now reach, what to me is the most interesting period, the time when electrical discoveries applied to the transmission of intelligence and to purposes of travel demanded the right to occupy the public highways.

About the year 1838, Steinheil and Morse contributed to modern civilization the inestimable boon of the telegraph.† It would be sophomoric to waste your time upon a description of what this discovery has accomplished. Suffice it to say that its great utility was universally recognized at once, and the promoters of telegraphic enterprise had little difficulty in securing a qualified right of occupancy along the highways for their poles and wires. Where the fee of the highway is vested in the public, the telegraph companies have never failed to obtain from public grant and without additional compensation for the use the right to erect their poles thereon in such manner as would not interfere with public travel. Where the fee of the highway remains in the adjacent property owners and only the use of the highways for purposes of public travel has been condemned, the courts of different States have differed as to whether the telegraph companies are entitled to occupy the highway without additional compensation to adjacent owners.

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* As to status of street railroads in the highway, see :

Lewis on Eminent Domain, Sec. 124.
Barney . Keokuk, 94 U. S., p. 324.
27 N. Y p. 188, People *v.* Ker.
91 N. Y., p. 148, Mahady *v.* Bushwick R. R. Co.
114 N. Y., p. 437, Hussner *v.* Brooklyn City R. R. Co.
14 Ohio State Rep., p. 523, Street R'way *v.* Cumminsville.
27 Wisconsin, p. 194, Hobarb *v.* Milwaukee.
17 New Jersey E., p. 76, Hinchman *v.* Paterson Horse R. R. Co.
79 Maine, p. 363, Lewiston, &c., R. R. Co. Androscoggin.
28 Mich., 62, Grand Rapids & I. R. R. Co. *v.* Heisel.
125 Mass., 515, Atty-Genl. *v.* Metropolitan R. R.
32 Conn., 570, Elliott *v.* Fair Haven and Westville R. R.
33 N. J. Eq., 267, Citizens' Coach Co. *v.* Camden Horse R. R. Co.
44 Cal., 414, Shea *v.* Potters and Bay View R. R. Co.

And even steam street railways so operated on street as to be consistent with the use of street in usual modes have been admitted. See

Newell *v.* Minn., L. & M. Railway Co., 35 Minn., 112.
Fulton *v.* Short Route R'way Transfer Co., 85 Ky., 640.

† Shaffner's Telegraphic Manual, Edit. 1859, p. 157.
Electricity and Electric Telegraph, by Prescott, Edit. 1887, p. 282.
Noad's Manual of Electricity, 1859, p. 772.
"Physique," by Daquire, Tome 3, p. 832, Edition 1867.

The decisions of Massachusetts and Virginia are diametrically opposite upon this question. In Massachusetts, the conclusion that they are not liable to adjacent proprietors is reached, by what seems to me exceedingly curious and strange ratiocination. It is admitted that the highway was condemned for use by the people for purposes of travel, and that such use is qualified and limited by the needs of the traveling public. But the Supreme Court of Massachusetts then proceeds to deduce the right of the telegraph to occupy the highway under such condemnation by arguing that one of the leading purposes of travel when the highway was thus condemned, was the transmission of news, at that time accomplished by persons on foot or on horseback or in vehicles. From this it is argued that the transmission of news, having thus been one of the primary objects of travel upon the highway, and the telegraph being but an improved method of transmitting intelligence, it properly occupies the highway with its poles and wires, and its presence is not a burden additional to those imposed upon the highway by the original dedication.

The Virginia decision on this same question seems to me to be much more plainly right and less sophistical. It holds, in broad terms, that public travel was the primary object for which the highway was dedicated; that when only the use for that purpose was condemned, and the title, subject to that use, was left in the adjacent proprietor, every use of the highway not in the line of travel, is an additional burden, for which the party so using must make additional compensation to the proprietor of the fee, before he shall be entitled to enjoy the occupancy. It rejects the reasoning of the Massachusetts Court, which makes a telegraphic message on a wire a traveler upon a public road. A foot-note hereto attached, shows the decisions of the various States supporting the Massachusetts and Virginia decisions respectively.*

Thus stands the telegraph on the highway. In every State, no matter what the decision as to its relation to adjacent proprietors, it is compelled to erect its poles and wires so as not to interfere with travel on the highway, and to remove them wherever it does so interfere with the primary, dominant use, public travel, to which the highway is confessedly appropriated.

The next claimant of a place upon the highway was the telephone. Again, I might pause to deliver a panygeric upon this great aid to business and intercourse, the merits of which discovery, by the uncertain fortunes of litigation, have been awarded to Alexander Graham Bell. But I forbear. A panygerical lawyer is always suspected of

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*Virginia decision in Western Union Tel. Co. *v.* Williams, decided in 1890 by Court Appeals, not yet reported.

Sustaining this general view, see also

60 N. Y., p. 510, Blanchard, &c., *v.* W. U. Tel. Co.
55 Barbour, p. 404, Knox *v.* Mayor, &c.
90 N. Y., p. 122, Story *v.* Elevated R. R. Co.
51 Hun, p. 590, Sheldon *v.* W. U. Tel. Co.
50 N. Y. Superior Ct. Rep., 488, Met. Tel. Co. *v.* Colwell Lead Co.
Ibid., p. 464, Tuttle *v.* Brush Elec. Co.
2 Ohio Cir. Ct. Rep., p. 259, Smith *v.* Tel. Co.
3 Ohio Cir. Ct. Rep., p. 425, Mt. A. & E. P. Inc. Pl. R'way *v.* Winslow *et als.*
107 Illinois, p. 507, Board of Trade Tel. Co. *v.* Barnett.
34 Northwestern Reporter, p. 337, Willis *v.* Erie T. & T. Co., from Minnesota.
Ibid., 37 Minnesota, p. 347.
13 Washington Law Reporter, p. 461, Hewitt *v.* W. U. Tel. Co.
Rhode Island Supreme Court, January, 1890, Taggart *et al.* *v.* Newport Street Railway, not yet reported.
42 N. J. Equity, p. 141, Broome *v.* N. Y. & N. J. Telephone Co.
11 Abb. New Cases, N. Y., p. 440, Dusenbury *v.* Mut. Tel. Co.

being in the same condition as a paragorical baby, more occupied with other portions of his person than his brain. It was not until 1878 that the telephone became a practical and useful adjunct of business. Since then it has grown in public favor, and multiplied its exchanges and subscribers in every part of the country, until it has become as much a part and almost as much a necessity of our business as any instrumentality we employ. It is of the very life and essence of the telephone that its poles and wires should occupy the public highway. The places which it seeks to reach, and which desire to communicate with each other, are nearly all upon the public highway; and it is essential to have its wires strung upon such accessible points for inspection and repair. Its interferences with public travel are no greater than those of the telegraph wires, although the number of its wires makes them more unsightly. In the earlier legal questions which arose as to its status upon the highway the Courts soon classed it in the same category with the telegraph, and assigned to it such qualified and subordinate rights and occupancy

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Dillon on Municipal Corp'ns, 4th Edition, Sections 698 and 698a.
But *contra*:
136 Massachusetts, p. 75, Pierce *v.* Drew.
88 Missouri, p. 258, Julia Bdg. Assn. *v.* Bell Tel. Co.
12 Mo. App., p. 485, Gay *v.* Mut. U. Tel. Co.
As germane to the question, see also
Gilbert's Case, 70 N. Y., p. 361.
Story's Case, 90 N. Y., p. 122.
Lahr's Case, 104 N. Y., p. 268.
Brooklyn Steam Transit Co., 78 N. Y., 524.
Sadler's Case, 104 N. Y., p. 229.
Cable Co.'s Case, 104 N. Y., pp. 38, 43.
N. Y. Dist. Ry. Case, 107 N. Y., p. 42.
Lewis on Eminent Domain, Secs. 635–637; also 131 and 226.
19 Kansas, p. 517, Tel. Co. *v.* Rich.
85 Kentucky, p. 640, Fulton *v.* Short Route R. W. Trans. Co.
Washburn on Easements, 252.
53 Alabama, p. 211, New Or. Tel. Co. *v.* Southern Tel. Co.
37 La. Ann., p. 68, Irwin *v.* Tel. Co.

of the highway as the telegraph enjoys.* With the methods of propulsion in vogue on the highway when the telephone was introduced, it had little controversy, although as it is constructed in many places, it was born a jealous child, delicate, sensitive, and irritable from its infancy, and subject to disturbances from all its neighbors. The electric current employed by the telephone, in whatever way it is constructed, is infinitesimal. It is merely employed to make the wires of the telephone sensitive to the sounds of the human voice and to cause them to produce responsive vibrations from one end to the other when the voice is applied at either end. The current employed by the telephone is a battery or static current, which is continuous, unvarying and makes no sound upon the wire. The current usually employed by the telegraph is also a light battery current, although a dynamo current is sometimes employed. The telegraph, unlike the telephone, uses its current directly for the transmission of intelligence. The Morse characters by which it makes itself intelligible are recorded by making and breaking the current over its wires. Notwithstanding the telegraphic current is so light, the jealous telephone, wherever constructed upon grounded circuit in its neighborhood, catches up the sounds from the telegraph and is disturbed by it. In several cases which I have tried, it has appeared in testimony that where the telephone and telegraph lines, constructed on what is known as the grounded circuit, ran parallel to each other for any considerable distance, even at a distance as great as 30 feet apart, so sensitive is the grounded telephone, that the Morse characters transmitted over the wires of the telegraph line could be read off the neighboring telephone by an experienced operator simply by placing the receiver of the telephone to his ear. This was due in great measure to the phenomenon of induction, a phenomenon which I shall discuss and explain later on.

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* Atty.-Gen. *v.* Edison Telephone Co., 6 Q. B. D., 244; Wisconsin Tel. Co. *v.* Ohskosh, 62 Wis., 32; 66 Md., 399, 410.

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But little legal conflict arose between the telephone and the telegraph. The telegraph had nothing to complain of, and the telephone, so long as only disturbed by the telegraph, was content to protect or remove its wires beyond disturbance by the telegraph, not only because the telegraph was the oldest in occupancy of the highway, but, because, I suspect, in most places, the two were owned by friendly interests.

Thus matters stood until 1880, when electric lighting was introduced, and then we have the third and fourth electrical occupants of the public highway; for electric lighting is of two kinds, to wit, arc lighting and incandescent lighting. Both these new industries employed the dynamo, which now appears for the first time upon the highway as a factor in the generation of electricity. Here again is the occasion for a vivid description of a wonderful discovery, quickly seized upon by every one and growing very rapidly into immense popularity and usefulness. Ten years ago electric lighting existed nowhere; to-day the street, park, hotel or public place in any populous community without both arc and incandescent lights is regarded as behind the times and unfit for real enjoyment. The use of the public highway is as indispensable to the lighting industry as it is to the telegraph or to the telephone, and for the same reasons. The light sold by these industries is generated in a method entirely different from the method of generation employed by the telegraph and telephone, and although both arc and incandescent light systems use the dynamo, their respective methods of using the dynamo-current are entirely different.

Let me explain for a moment. I shall use the terms "amperage" and "voltage" hereafter. They are strange terms to you, but can soon be made familiar. Once understood, they will be as intelligible terms as the words "gallon" or "hydraulic pressure." The word ampere relates to the quantity of electricity, and the word voltage describes the electrical pressure under which a current of electricity is sent out. The following question put to Thomas A. Edison and his answer thereto in one of the cases in which

I examined him will forever doubtless fix the meaning of these terms in your mind:

" Q. Explain what is meant by the number of volts in " an electric current?

" A. I will have to use the analogy of a waterfall to " explain. Say we have a current of water and a turbine " wheel. If I have a turbine wheel and allow a thousand " gallons per second to fall from a height of one foot on " the turbine, I get a certain power, we will say one horse " power. Now the one foot of fall will represent one volt " of pressure in electricity, and the thousand gallons will " represent the ampere or the amount of current; we will " call that one ampere. Thus we have a thousand gallons " of water or one ampere, falling one foot or one volt or " under one volt of pressure, and the water working the " turbine gives one horse power. If, now, we go a " thousand feet high, and take one gallon of water and " let it fall on the turbine wheel, we will get the same " power as we had before, namely, one horse power. We " have got a thousand times less current or less water, " and we will have a thousandth of an ampere in place of " one ampere, and we will have a thousand volts in place " of one volt, and we will have a fall of water a thousand " feet as against one foot. Now the fall of the water or " the height from which it falls is the pressure or volts in " electricity, and the amount of water is the amperes. It " will be seen that a thousand gallons a minute falling on " a man from a height of only one foot would be no danger to the man, and that if we took one gallon and took " it up a thousand feet and let it fall down it would crush " him. So it is not the quantity or current of water that " does the damage, but it is the velocity or the pressure " that produces the effect."

A word further of explanation.

Electricity may be classified with reference to the methods of its generation as of three sorts:

First.—Natural electricity—that is to say, lightning and all other electric manifestations of nature;

SECOND.—Battery or static electricity, which is generated in cells or batteries by the dissolution of chemicals; and

THIRD.—Dynamic electricity, which is generated from a dynamo.

I need not discuss the first.

As to the second, the currents generated in batteries are not large, although by combining a number of cells quite a large current may be obtained. One characteristic of all such currents is that they are absolutely continuous and steady, not varying in any perceptible degree except that they gradually grow weaker and die out as the chemicals are exhausted.

As to the third, dynamo currents are very powerful currents. They are called continuous, fluctuating and alternating currents, as hereafter described.

I am sure that my hearers would be astonished to behold the simplicity of construction of the dynamo from which such death-dealing and blessing-dispensing power emanates. Upon an iron core a great length of wire is wrapped back and forth, its terminals being carried to a cylinder on the end of the axle called the commutator. This coil of wire is placed within the field of a powerful magnet, it is belted to steam power and the coil of wire is revolved rapidly within the field of the magnet. This action generates a volume of electricity.

The quantity which may be generated thus depends upon the size of the dynamo employed and the rapidity of revolution.

The normal flow of the electricity thus generated would be directly from one terminal to the other of the coil. By the interposition of a good conductor the current can be taken to great distances and utilized for light or power. By means of devices, known as brushes and copper wires, the current is led away from the generator to the point or points where it is to be used. To utilize electricity at all, what is known as a complete circuit must be established; that is to say, the current, however far away it may be led, must be, by one means or another, conducted back from the positive to the negative pole of the generator.

When this is done a circuit, as it is called, becomes established, and only when this circuit is complete does the presence of electricity manifest itself, or is it available for any purpose.

About 1838 Steinheil and Morse simultaneously discovered that the earth would supply a return conductor for all generated electricity; that is to say, that conducting the positive current upon wire to any distance from the generator, and connecting the negative pole of the generator to the earth, the circuit could be established by inserting the end of the positive wire into the earth even at great distances from the generator. The surface of the earth is filled with electrical conductors. So great is its conductivity that electricians frequently refer to the "infinite conductivity" of the earth. The first inventions in telegraphing had used wire for the return as well as the outgoing current. Whenever currents are thus conducted throughout their entire course upon wires, they are known as complete metallic circuits. Where the wire is used only for the outgoing current, and the circuit is completed by using the earth, the circuit is known as a ground circuit. I shall have occasion to refer again to this matter of grounded and metallic circuits.

Both arc and incandescent lighting are accomplished through pure metallic circuits for many reasons.

Let me now describe the general features of arc lighting.

Being provided with a steam plant to drive the dynamos, and dynamos of sufficient generating capacity, wires are strung from the generator on poles from which they are carefully insulated to the point to be lit. Light is made wherever needed, by a break in the continuity of these wires. Wherever such break is made the broken ends are kept in close proximity, and the current leaps across the breach. This is known as an electric arc. Wherever such an arc occurs it produces intense heat. Availing themselves of this knowledge, electricians place upon the tips of the broken wire, at the point of breach, a substance which, under great heat, possesses the quality of incandescence. Thence the wire proceeds to the next point where a light is needed, and there another break in the wire is made and the breach provided with incandescent tips, and so on throughout the circuit, until the wire is brought back to the negative pole of the generator. When the dynamo is started, light is secured at each break by the heat of the electric arc producing incandescence in the substance provided for that purpose at the points where light is desired.

I will not weary you with the details of the contrivances for regulating these lights or cutting them out of circuit.. A powerful current is necessary to produce the arc lights. It is procured by large dynamos furnishing great quantities of electricity, which is driven out under an immense pressure as high as 2,000 to 2,500 volts, each light requiring about fifty volts. This voltage of electricity is deadly. A person receiving a full shock of a current of that voltage would be instantly killed. For that reason great care is taken in the construction of arc light wires, and they are invariably built not only on pure metallic circuits, but the wires are thoroughly surrounded by insulation to prevent accidental contacts or escape of current.

The current employed in arc lighting is what is known as a continuous current; that is to say, it flows always in one direction, with as little variation in intensity as practicable. But it differs from static or battery currents in this that, whereas they are of a steady intensity or potential, as it is termed, no dynamo has as yet been invented which gives an absolutely steady current. Either from irregularities in the speed with which the generator revolves or in the material used in its construction, or from one or more of many other causes I might name, the most perfect dynamo current is a fluctuating current, varying in intensity from moment to moment. This variation of current creates in the wires over which it passes a humming, or a buzzing or a crackling sound, not heard in battery currents.

Theoretically, the arc light wires are entirely insulated from the earth. The natural tendency of all currents is to seek the earth and there disperse through its infinite conductivity, just as lightning upon reaching the earth disperses and becomes harmless. Wherever a current escapes to the earth from the wires of an arc light circuit, just so much power which could be utilized on the circuit is lost; therefore, great pains are taken to insulate the wires at their support on the poles. Notwithstanding every precaution and device, a perfect insulation has not yet been found, and more or less current escapes across all the insulations yet devised, making its way to the earth along the poles. In the same way leakage occurs from accidental contact with other conductors. This is called earth leakage. This has been the source of much litigation.

Another electrical phenomenon, and one which has played a very prominent part in all the litigation which has arisen between electrical enterprises, is known as "Induction." It is a well-known fact in electricity, that where a wire charged with a heavy current of electricity is strung parallel for a considerable distance to another wire upon which there is no electric current or a much weaker current, the strongly charged wire excites in the weaker wire a sympathetic current, which moves in the opposite direction, but vibrates, pulsates, crepitates, and in all respects reproduces the manifestations of the current on the stronger wire. The distance at which this phenomenon will be produced, varies considerably according to the intensity of the exciting current, the size of wire and atmospheric and other conditions. A knowledge of this phenomenon of induction supplies the means employed by some systems of incandescent lighting.

Incandescent lighting, as practiced by several of the systems in vogue, differs from arc lighting materially. In many systems the wires from the generating plant are carried to the outside only of the buildings where the incandescent lighting is to be done, and there they are placed in a coil in close proximity to, but not in contact with another coil of wire in the building to be lighted. From this last-named coil, called the "induction coil," wires are carried to the glass bulbs which we see on every hand, in which are placed carbonized loops. Under the systems resorting to the method, the incandescent lights in the building are produced, not by the introduction into the building of the original current, but by the sympathetic or induced current described above, set up in the induction coil from the passage of the direct current on the wire and coil outside the building.

The dynamo current employed for such systems of incandescent lighting is entirely different from that used in arc lighting, being what is known as an "alternating" current. The alternating current is produced by reversing the poles of the magnet as rapidly as possible, thus making the electric current flow back and forth in opposite directions many times a second. This alternating current is of great intensity, is the noisiest of all currents upon the wires, and is fatal to human life at a much lower voltage than a continuous current would be.

No sooner did electric lighting appear than a great cry went up from the telephone. The telephone had been constructed upon a grounded circuit almost everywhere, using the earth for its return current. That form of construction was by no means as good as a complete metallic circuit, but it was much cheaper and fairly efficient, barring the vicinity of other electrical enterprises, and none such, save the telegraph, were present to disturb the telephone when it was first built. But when the electric light companies began to string their wires in the highway in the neighborhood of and parallel to the grounded telephone, war was inaugurated on the spot. Wherever any leakage occurred from the electric light wires the fugitive currents thus let loose, in returning through the earth to their source, took the best conductors they could find. For, while electricity discharged into the earth returns to its source, the course of its return is not direct. It pursues the best conductors it can find, preferring metals, damp earth, veins of minerals, &c., and above all delighting to course over gas and water pipes, electric wires and the like, which lie in its way. The telephone companies, in seeking the earth for their return currents, had almost everywhere attached their wires to the gas and water pipes, inviting this very class of disturbance, and the result was a truly absurd hubbub upon their grounded wires. The leakage from the electric wires rung their alarm bells, knocked down their annunciators, occasionally burnt out their instruments, gave false calls, and clicked and buzzed and hummed away in their grounded wires to such an extent as greatly to annoy their patrons. Besides this earth leakage, wherever parallelism existed between their wires and the electric light wires inductive noises appeared in the telephone wires to such extent as frequently to drown the human voice in its effort to project itself over the wires of the telephone.

A great deal of litigation ensued between the light companies and the telephone. There was no doubt that either the one or the other of these companies could prevent these disturbances. The telephone had it in its power, by putting up a complete metallic circuit to relieve itself of troubles both from induction and earth leakage; for by bringing the return current back upon a wire parallel and in close proximity to the outgoing wire the two so operate upon each other as to create around themselves a protective field which is not penetrated by inductive disturbances from any neighboring circuit, and this arrangement prevents the wire itself from producing such disturbances on other wires. And as by that form of construction the telephone would nowhere come in contact with the earth, it would then be absolutely free from earth leakage as well as from disturbances by induction. These facts are admitted by every telephone expert It is conceded that the pure metallic circuit telephone is the ideal form of telephone construction. The first telephones invented were on the metallic circuit. All long distance telephone systems now in use actually employ the metallic circuit. It is almost the only form of construction employed throughout the Dominion of Canada, and in many cities of America it is rapidly being adopted as the only refuge from the disturbances arising from neighboring electric circuits unless the others are driven out entirely.

But the system of grounded circuits was much cheaper for the telephone, and it was not disposed to yield that economical method to the electric light companies, especially as the electric light companies could also use parallel return wires, remove their wires to some distance from the telephone, were the last comers, and had no better title in the highway than had the telephone itself. Many cases between the telephone and electric light companies were tried. In the majority of the cases the light companies were compelled to remove their wires to a sufficient distance from the telephones or to introduce parallel return wires to avoid inductive disturbances to their neighbor. On the whole, the telephone companies were much emboldened by their success against the electric light companies.

In 1887, came a new development in street railways, a development which was marvellous at its outset, and which, although no longer novel, is still wonderful beyond expression. The first electric street railway of any magnitude or importance in the United States was built in Richmond, Virginia, by Frank J. Sprague. It will be hard to find a locality where the conditions were more difficult. Richmond is a very hilly city, lying upon the banks of the James River, much as Albany lies upon the Hudson, save that Richmond is divided up by three or four valleys, transverse to the course of the river. Yet it was found practicable to substitute electrical propulsion for horses upon the street car system of that city. When the project was first bruited, it was looked upon as rash to the point of folly. When it was consummated, the universal wonderment may be best expressed by the story of an old colored man, who for the first time seeing an electric car mounting a ten per cent. grade, without any visible means of propulsion, threw up his hands and exclaimed, "Fo' God, what is the white folks gwine to do next? When de niggers was freed, we said dey would all starve, and now dey is not only got on

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widout de niggers, but has gi'n de mule a furlough." Within three years of that first experiment, electric railways have taken the place of horse cars in almost every great city of America, and I venture the prediction that within ten years from this day a horse car will be as rare a sight as the old-time spinning wheel of our grandmothers.

The different methods of electric street railway construction so far attempted are four in number:

First, the storage battery. That consists of a car provided with a motor, driven by electricity stored in the car. The general plan is to pump, so to speak, electricity into metallic sponges capable of receiving a vast amount. This is done at a generating station. These metals, saturated with electricity, are placed in the car, and electricity thus stored will theoretically drive the motor for a considerable time. When exhausted, the storage battery is replaced by a fresh one and recharged for another car. The storage battery is, beyond doubt, when perfected, the ideal method of electric street railway propulsion. But as yet I do not think it has proved a success. Experiments are still being made upon the Madison avenue line in New York, and at Beverly and Danvers, in Massachusetts, and Washington, D. C., with this system of propulsion; but the great difficulty to be overcome—a difficulty which is far from solved—is the rapid deterioration of the batteries and their great weight upon the car. The former makes the cost of running too great and the latter loads the car too heavily.

The second method of construction attempted was known as the conduit system, by which the wires conveying the electric current were placed under ground and the current was obtained for the motors through a slot on the surface of the earth. This method was tried in Denver, Boston, New York City and elsewhere, but has been virtually abandoned.

The third method of construction is known as the double trolley overhead system, which is an unsightly, expensive and cumbersome contrivance, used, I believe, in about six or eight towns, and endorsed only by a road in

Cincinnati, whose owners there also own the grounded telephone exchange.

The fourth method, the single trolley overhead system, is the only one which has proved financially and commercially successful, and is in use on nine-tenths of the railroads using electricity. Between this last named system and the American Bell Telephone Company a battle royal has been waged for several years, involving the modest claim set up by the telephone company to the exclusive use of the earth.

To understand this controversy, a brief description of the single trolley overhead system is necessary.

The steam plant and dynamos employed are similar to those described as used by electric light companies. The voltage of the current used is, however, nothing like as great. The current is a continuous current and, according to the testimony of electrical experts as well as the experience of a vast number of employees who have received the shock, the electric current now in use upon the street railway equipments furnished by the leading electrical supply companies is not dangerous to human life. But of this I shall speak again. The positive current of electricity from the generating station is conducted over the centre of the street railway track by a large wire suspended 18 feet in the air throughout the whole length of the track. The rails of the track are strongly united by copper connections, and in many cases a large copper wire is placed under the rails to which they are also attached from point to point. The terminals of the rails adjacent to the generating station are united to the negative pole of the dynamo or generator. The object of these things is to facilitate the flow of the return current. Thus we have, throughout the whole length of the railway, a copper connection with the positive pole, and an earth and metallic connection with the negative pole. But you will observe that our circuit is still incomplete, because at no point does the overhead positive wire provided for the outgoing current come in contact with or connect with the conductors provided for the return or negative current.

So long as this condition remains there will be no electricity on the line. It is by supplying the connection between the positive and negative poles that the motor completes the circuit, and the current furnishes it with the propulsive power upon the car.

An electric motor, as used on an electric car, is nothing but a reversed dynamo. It is constructed like a dynamo, and if used as a dynamo upon its end of the circuit, the dynamo may be converted into a motor upon its end. In a word, by artificially revolving the motor within the field of its magnet, and leaving the dynamo quiet, the motor would generate a current which would drive the dynamo at the generating station. The motor is placed underneath the street car and geared and pinioned to the axle so that when it revolves the axles and wheels of the car must also revolve. Its negative pole is connected with the iron work under the car and thereby to the axles and wheels resting on the rails. The positive pole of the motor is connected, by insulated wires running up through the body of the car, to an iron pole, or trolley, upon the top of which is a brass wheel. This pole is stimulated upward by spring devices so that, uncontrolled, it will maintain under-contact with the overhead wire first described. Thus we see, upon the car, the connecting link between the positive and negative poles of the generator, and thus it is that the moment the trolley wheel touches the overhead wire the circuit is established, the current begins to flow, the motor revolves, and the car starts. Whenever the trolley wheel is pulled down from the wire the current is thereby broken and the car stops. When the trolley wheel touches the overhead wire the current flows down through the trolley wheel, the pole and wires in the car, reaches the motor, forces its coil to revolve, passes on to the negative pole of the motor, thence through the axles and car wheels to the track, and thence, by means of the track, the supplementary wire, and the earth, returns to the generator.

I will be pardoned for a slight digression here, if I answer a question no doubt present in your mind, because it was a question which I often asked myself before I knew the answer. I hear you say, Why is it that persons stepping on the rail of an electric street railway just behind a car which has passed, are not shocked by the current flowing beneath their feet? The answer suggests another question : Why is it that swallows and little birds light on the overhead wire and are unconscious of the presence of the electric current rushing through their very claws? The answer to both questions is the same: The man and the bird are on but one side of the circuit; the current does not flow through them. One may swing by his hands upon the overhead wire unharmed, as he may stand with both feet upon the track; but if he were tall enough to reach, from the point where his feet rest on the earth, to the wire above, and seize it with his hands, instantly he would become the connecting link between the two legs of the circuit and the current will flow through him or, as it is called, short circuit through him, shocking him or killing him according to its strength.

The infinite conductivity of the earth is such that the electric street car current, when it passes from the wheels to the rails, cannot be confined, in its return, to the rails themselves. Released from his labors at the motor, this weird Ariel springs from the wheel to mother earth with the romp and playfulness of a boy let loose from school. Once in contact with the soil, the homeward course of electricity will not be confined to the straight and narrow path of any artificial conductor, however good, but seeking the moist earth and veins of minerals or metallic substances as they are reached in the return, it dances and plays along them as if delighting in its temporary release from the strict confinement of its master. Thus it is that the current, released at the car wheel, and starting back to the generator a mile away, it may be, may zigzag and wind back and forth through subterranean conductors far out of the direct course to its negative pole; and hence it follows that neighboring grounded telephones are ridden upon, and danced upon and rung upon, as truant elfs and goblins danced on Bottom in a Midsummer Night's Dream. The variations of the current in this class of street railroad circuit, and the noise of the dynamos and motors, are greater than that of the electric lights, and the parallelism of wires with those of the telephone more certain, so that the advent of this form of electric railway construction was a new torture, both by inductive disturbances and greatly increased earth leakage, to the grounded telephone systems.

In the street railways the telephone found no such weak adversary as it had in the electric lighting companies. In point of time the street railroad franchise was in most places older than that of the telephone. In point of fact, even before the discovery of the telephone the grants of street railroad franchises had embraced the right to use any method of propulsion then or thereafter discovered, except steam. In right of occupancy the electric railways were on the public highway exercising the very use for which the highway had been originally dedicated. In the use of the grounded circuit, the telephones themselves were simply enjoying the identical right possessed by the street railroads, and in order to deny the right of the street railroads to use the grounded circuit the telephone must itself establish that it was entitled to the exclusive use of the earth. Ordinarily, he who asserts an exclusive easement is compelled to show not only the priority and exclusiveness of his grant or use, but the source and boundaries of his title. The telephone made no attempt at this. It merely contented itself with saying that it had used the earth for its return circuit, was using it undisturbed until the street railway did the same thing, and was injured by its neighbor's use of the ground circuit, so as to entitle it to invoke the protection of the legal maxim *sic utere tuo, ut alienum non lædas.*

The answer to this contention seems to me to be conclusive. The street railways have never denied that both by induction and earth leakage their currents disturb neighboring grounded telephones, or other grounded electrical circuits whose efficiency is dependent upon quiet; but the point contended for was that all such damage was *damnum absque injuria.* It is not claimed that the use of the earth for the return current was a discovery appertaining to the telephone. On the contrary, it is admitted that forty years before the telephone was invented, Steinheil discovered the grounded circuit, and in this country Morse sought to obtain a patent on it and failed. From that time until 1879, the earth was used for a return current by all electrical enterprises desiring to use it. It was by this right, common to all, and by no other title, that the telephone exchanges were built upon the plan of ground circuits. Such being the source of their title, what are its boundaries? If the claim set up by the telephone, that it is not to be disturbed by other electrical enterprises through their use of grounded circuits, is good, surely it should define the boundaries of the territory devoted to its exclusive occupancy. Yet those boundaries are as incapable of definition as are the unknown and unknowable subterranean electrical conductors in the crust of the earth. Besides these inherent defects of title, the telephone had been admitted in almost every instance to its occupancy of the highway upon the express condition that it should not interfere with public travel thereon. It came as a vassal. Yet in a few years it asserted the title of a lord of the highway and sought to stop upon the highway the greatest outcome of modern invention for improved rapid transit thereon.

The American Bell Telephone Company is not only one of the richest monopolies in America, but has had almost unbroken success in litigation.

The confession had been made in the scientific papers, read at the annual telephone conventions held for several years past, that the grounded telephone system is very defective and unsatisfactory to the local operators and their patrons.

See articles of J. W. Lockwood and C. E. McCluer, read at Telephone Convention held in New York in September, 1888. Also article entitled "New Era in Telephony," by Hibbard, Pickernell and Carty, at Convention, 1889, in Minneapolis, both published in *Electrical Review.*

Metallic circuit telephones are confessedly superior to grounded telephones in every way, and obviate all the disturbances experienced in the grounded systems. What is known as the McCluer device, by which, even on grounded telephone systems, disturbances from earth leakage are altogether, and disturbances from induction are substantially, overcome, had been successfully used in many cities.

See article of C. E. McCluer, *supra*. Also his deposition in the Nashville case, before Judge Brown.

The articles above quoted had called the attention of the American Bell Telephone Company to the fact that its exclusive patents expire in 1893, when its competitors will be admitted, and warned it of its danger if it shall continue to adhere to the cheap and inefficient structure of grounded telephones, and the new companies organized upon the expiration of its patents shall come in and offer the public the better service of metallic circuits; the universal adoption of metallic circuits throughout Canada, and the increasing demand for them in the United States—at New Haven and elsewhere. All these considerations were doubtless presented to and considered by the American Bell Telephone Company before it resolved upon a general attack on the best known system of electric car propulsion, in order to preserve the worst known but cheapest system of telephones.

But it resolved to make the test and its campaign was inaugurated by a bill filed in a State court at Akron, Ohio, against the Akron Street Railroad and the Sprague Electric Railway and Motor Company, supported by elaborate affidavits of its leading experts as to the character and causes of the disturbances to which it was subjected from the leakage and induction of the current there used by the Electric Railway.

My professional brethern will, I am sure, accord me full measure of their profound, if amused, sympathy as they consider what my feelings were when I first perused that bill, and considered that the duty of preparing an answer to it rested upon my shoulders. If it had been in Greek with exhibits in Hebrew, Sanscrit, and higher mathematics, it would hardly have been less intelligible to me. I had sometimes regretted that legal practice and principles contained so little of novelty and had longed for something new and exciting in law. That ambition was at least satisfied. Volts, amperes, dynamos, armatures, earth currents, induction and a thousand other strange terms chased each other in confused troops through a bewildered brain, and seemed to trample to death the very power of connected thought. It seemed as if a new liberal education was a necessary preliminary to any understanding by me of the facts set forth in the bill. When this should be accomplished, would come the still more important part, viz.: a discovery of the legal principles applicable to the comprehended facts.

This latter branch involves a wide range of study. A study, first, of the whole range of nuisance decisions, as invoked by the complainant, and then the respondent's defensive line, which lay to a great extent in reasonings from analogies. Analogies from decisions upon the rights of railways to do incidental damage without liability.

Analogies from decisions as to the rights of riparian proprietors upon water courses. Analogies from decisions as to the diversion or pollution of percolating streams which flow by unknown routes beneath the surface of the earth.

Analogies from the incidental but necessary injury to adjacent streams from the lawful use of mines, &c.

These are but a few of the many authorities bearing on our defense. A foot-note contains a list of those which I conceive to be the most instructive on the question of *damnum absque injuria.**

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* Cases as to *damnum absque injuria :*

Wood *v.* Sutcliffe, 2d Simons' Rep., New Series, p. 168. *Ib.*, 16 Jurist, p. 75. *Ib.*, 8 Eng. L. & E. Rep., p. 217.
Irwin . Dixion, 9 Howard (N. Y.), p. 10.
Mohawk Bridge Co. *v.* Utica & Sch. R. R. Co., 6 Paige, 554.
Dillon *v.* Acme Oil Co., 49 Hun, p. 565.
Frazier *v.* Brown, 12 Ohio State Rep., p, 294.
Penn. Coal Co. *v.* Sanderson, 118 Penn. State Rep., p. 141.

Other suits instituted in the names of the local licensees of the American Bell Telephone Company, but really instituted and conducted by it, quickly followed the Akron case in Harrisburgh, Pa.; Chattanooga, Tenn.; Salt Lake City, Albany, Cincinnati, Wichita, Kas.; Eau Claire, Wis.; Knoxville, Nashville, and elsewhere. If any doubt had theretofore existed as to the central origin of these suits it was dispelled by the identity of the bills and affidavits of experts filed at all these points, and the band of telephone experts and street railway lawyers who traveled from one city to another as these hearings came on was like a wandering company of actors meeting their engagements. By the time I had learned my part it was too late to teach it to any other lawyer before the hearing could be reached, and as a consequence, I became the Nelly Bly of the legal profession, practicing law in seventeen States in seventeen months, and studying the statutes of different States successively until I scarcely knew what State and law belonged to each other.

Without further detaining you with the recital of the

Penn. R. R. Co. *v.* Marchant, 119 Penn. State Rep., p. 541.
Cassady *v.* Cavenor, 37 Iowa, p. 300, particularly p. 305.
Galvin *v.* Coal Co., 9 Ch. App., 706.
Panton *v.* Holland, 17 Johns., 92.
Thurston *v.* Hancock, 12 Mass., 220.
Clarke *v.* Foote, 8 Johns., 421.
Platt *v.* Johnson, 15 Johns., 218.
Lansing *v.* Smith, 8 Cow., 148.
Gilman *v.* Philadelphia, 3 Wall., 713.
Snow *v.* Parsons, 28 Vermont, 459.
Cooley on Torts, p. 587.
Smith *v.* Washington, 20 Howard, 135.
Transportation Co. *v.* Chicago, 99 U. S., 635.
Callender *v.* Marsh, 1 Pick., 413.
Ratcliffe's Exrs. *v.* Mayor, 4 N. Y., 195.
West Cumberland Iron & Steel Co. *v.* Kenyon, 11 Ch. Div., 788.
Atty.-Genl. *v.* Colney Hatch Lunatic Asylum, L. R. Ch. App., 146.
Rockwood *v.* Wilson, 11 Cush., 226.
Hoyt *v.* Jeffers, 30 Mich., 181.
Balt. & Pot. R. R. Co. *v.* Fifth Bapt. Ch., 108 U. S., 317.
Heerman *v.* Beef Slaugh. Co., 8 Bissell C. Ch. Rep., p. 334.

arguments, pro and con, in the widespread litigation between the electric street railroads and the telephone, I will state the results, giving citations of the cases in a footnote. All the decisions have been in favor of the street railways except one in Cincinnati, and that has been appealed. The courts of last resort have not yet disposed of the question finally. Even the decision rendered in the Court of Appeals of New York cannot be cited as conclusive, for the matter is still pending there. Very able opinions sustaining the views of the street railways have been rendered in the Federal Courts of Utah, by Judge Zane; in the Circuit Court of the United States, at Nashville, by Judge Henry R. Brown, who sat there for Judge Jackson, disqualified. From these no appeals are pending. Decisions have been rendered in a number of other inferior courts in favor of the street railways. In the Superior Court of Cincinnati an adverse opinion was rendered by Judge Taft, which opinion was sustained by two out of three of the Judges of the same Court sitting in General Term. The case is now on appeal to the Supreme Court of Ohio.

In Wisconsin the decision at Eau Claire was in favor of the railroad, and the Telephone Company took an appeal to the Supreme Court of Wisconsin, which appeal is still pending.*

These cases have come up, as a rule, before Judges of singular ability, and since the litigation arose two of the

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* Cases against Street Railways:

1. Cen. U. Tel. Co. *v.* Akron Street R'way and Sprague Elec. R. W. & Motor Co. Common Pleas Court at Akron. Injunction refused.
2. Penn. Tel. Co. *v.* E. Harrisburg Street R. W. Co. and Sprague Elec. R. W. & M. Co. Compromised.
3. E. Tenn. Tel. Co. *v.* Chattanooga, &c., Street Railway Co. Injunction refused.
4. Rocky Mountain Bell Tel. Co. *v.* Salt Lake City Railway Co. U. S. Dist. Ct., Utah. Injunction refused.
5. Wisconsin Tel. Co. *v.* Eau Claire Street Railway and Sprague Elec. R. W. Co. Circuit Court of Eau Claire. Injunction refused. Appeal pending.
6. City & Sub. Tel. Co. *v.* Cin. Incl. Plane R'way Co. Injunction granted by Judge Taft. Affirmed by General Term. Appeal pending.

Judges who decided them have been "struck by lightning" in another form, Judge Taft having been appointed Solicitor-General of the United States, and Judge Brown having been nominated as Associate Justice upon the Supreme Court of the United States.

I cannot leave this branch of the subject without allusion to and quotation from an opinion delivered by Chancellor Gibson of Knoxville, when he refused the application of the Telephone Company for injunction. I cannot commend it particularly as a model of calm judicial utterance, but as a specimen of vigorous Western American talk it has few rivals:

" It must be remembered that the Telephone Company " does not claim any particular right of way or strip or " piece of ground, or any particular streets or alleys with" in the limits of Knoxville for its earth circuit, but it " claims the whole of the surface of the earth and all that " is beneath the surface of the earth within the corporate " limits as its exclusive property for all the purposes of " an earth circuit.

" Now, if at the time this ordinance was passed any one " had suggested that this limited privilege of 'erecting " poles' gave to the Telephone Exchange a right to use " all the ground on which the city stood, public and pri" vate, as an easement to be used in place of wires, to " complete its electrical circuit, he would no doubt have " been regarded as a willful distorter of language. But if " in addition he had claimed that this meagre privilege of " 'erecting poles' not only gave the Telephone Exchange " a right to use all the ground, public and private, within " the corporate limits, as its own, but the right to use it

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7. Hudson R. Telep. Co. *v.* Watervliet T. & R. Co. Supreme Ct., Albany. Injunction dissolved. Appeal pending.
8. E. Tenn. Tel. Co. *v.* Knoxville Street R. R. Co. Chancery Court, Knoxville, Tenn. Injunction refused. No appeal.
9. Cumberland Tel. & Tel. Co. *v.* United Electric R. W., &c. Cir. Ct. U. S. Judge Brown. Injunction refused. No appeal.

Have copies of all these, and will gladly furnish any person desiring them with copies of all such as are unreported.—I. S. W.

" to the exclusion of all the other electric companies from " now to the ending of the world, he would have been regarded as a wicked exaggerator, if not a deliberate " falsifier. And yet this is exactly what the Telephone " Company claims in its bill.

" I am unable to so construe the scant 'privilege of " erecting poles' so as to make it 'grant the right' to the " exclusive use of every inch of ground within the corporate limits, for all the purposes of an earth circuit for " electricity. Such a grant could never have been in the " minds of the Mayor and Aldermen, and I am unable to " find these exclusive rights and monopolistic powers condensed in five such harmless words as 'the privilege of " erecting poles.'

" The Telephone Company, however, does not content " itself with literally claiming the exclusive right of the " whole of the earth on which Knoxville is built, for its " return electrical currents, but it claims a monopoly of " the whole of the air also, and insists that no other electrical company can string its wires in the near neighborhood of the telephone wires. And thus the simple " privilege of 'erecting poles' on the side of the streets of " Knoxville is magnified into a grant of the exclusive " right to all the earth and all the air within the corporate " limits of Knoxville, for all electrical purposes, except " telegraphing.

" But it may be urged that the ordinance says that 'this " privilege of erecting poles shall be confined to Telephone " Exchange purposes exclusively.' So it does, but will it " be contended that these words, which are rather words " of limitation than of extension, give the Telephone Company the exclusive right to use every inch of Knoxville's " ground, and a superior right to all of its air, as its private " property for electrical purposes?

" And thus it is, this once humble Telephone Company " that was given the bare privilege of 'erecting poles' " on the edge of the curbing, now comes forward, and by " virtue of those two talismanic words, claims the right " to make the Electric Light Companies, the Electric Rail-

" road Companies, and all other Electric Companies, for
" all time to come, keep their wires from communicating
" with any part of the ground on which the city stands,
" or else pay it for the privilege of so doing. In a word,
" it claims perpetual monopoly of the earth on which the
" city is built, for all the uses of an electrical circuit; and
" also, claims a superior right to the air itself for electrical
" purposes.

" Ordinarily a person's strength consists in his physical
" powers, but the Telephone Company's strength is sought
" to be derived from its weakness; it says that its elec-
" trical current is so weak that all strong currents greatly
" affect and impair its usefulness, and that, as a con-
" sequence, no company using a strong current can law-
" fully use the earth for a return circuit without its leave.
" If this contention be correct, then no electrical company
" can ever use the underground of which Knoxville is
" built without the consent of the Telephone Company.
" It makes no difference what grand discoveries and in-
" ventions in the use of electricity may be made; coal,
" wood, gas, steam and animal power may all be super-
" seded by electrical devices; machines may be invented
" to heat and light all of our homes, do all of our cooking,
" propel all our vehicles and machinery, and all or a large
" part of this electricity may be drawn from the earth,
" or it may be drawn from the air, and yet Knoxville and
" all her people are to be denied all of these wonderful
" benefits, for all the ages to come, if they, either through
" the earth or through the air, in any way cripple or
" injure the feeble current of the Telephone Company—
" unless the Telephone Company gives or sells its con-
" sent. Well might one exclaim, in the language of
" Cassius, when talking of Cæsar's former weakness and
" present power,

" Ye Gods, it doth amaze me,
A thing of such a feeble temper
Should so get the start of the majestic world
And bear the palm alone."

One of the attorneys for the Telephone Company remarked, when the Chancellor finished, that he felt as if the Judge had shot him with all five barrels of his revolver, stabbed him back and front, thrown him down three flights of stairs into the street, and was now sitting on the dead body picking his teeth with his bowie-knife, and explaining his reasons for the homicide. Besides the pleasure of practicing before such eminent men, the privilege has been mine of consulting with and examining in the preparation of these different causes nearly all the most eminent authorities in America upon electrical subjects: Edison, Sprague, Prof. Elihu Thomson, Professor Dolbear of Tuft's College, Professor Cross of the Boston School of Technology, Daft, Van de Poele, Short, S. Dana Greene, O. T. Crosby, Mansfield, and a host of lesser lights. My professional brethren will understand my meaning when I speak of the opportunity to examine such brilliant and accomplished men as a privilege as well as an education in itself.

But over and above all these I shall ever cherish in grateful remembrance the great aid given me by my brethren of the Bar in many sections of the Union; nowhere more ably rendered than in the good City of Albany, where my associates were your distinguished president, and the Messrs. Hun.

Remembering the bright minds from which I have learned so much by contact, and the noble fellows both colleague and adversary into whose society and companionship I have been brought, and whose hospitality I have enjoyed, I more than ever appreciate why it was that the judges and lawyers of the olden time looked upon the days of the Circuit as the golden era of the profession.

The great telephone controversy is by no means the only litigation which has arisen from the occupation of the highways by the electric railways.

No sooner did their poles, wires and currents appear than they were attacked by sundry other assailants and on many grounds.

In Ohio, Rhode Island, Indiana, New York and elsewhere, proceedings were instituted in some cases questioning the right of the railways to erect poles and string wires in the highway, and averring that thereby they subjected it to an additional burden; in other seeking to abate them as nuisances, dangerous to life and property.

Touching the cases in which the claim was set up that the poles and wires of electric railways like telegraph and telephone poles and wires were additional burdens to the highway, the courts of Ohio, Rhode Island and elsewhere, promptly drew a distinction between the two. They held the railway poles and wires to be auxiliaries of a new improved method of travel on the highway and therefore not an additional burden but strictly in the line of use for which the highway was originally condemned. These decisions have been uniformly one way.*

The struggle against the erection of the electric railway poles gave rise to an amusing episode which I cannot resist narrating :

Certain patrician residents of Newport resolved to oppose the introduction of the plebeian Electric Street Railway there. The overhead poles and wires of the railway were regarded by certain abutting owners as creating an additional burden on the highway for which no compensation had been made to them. On this ground they sought an injunction restraining their erection. Not content with the advice of local counsel, they procured the opinion of one of the most eminent as well as honored and beloved lawyers and law writers of New York. The opinion was strongly in their favor, citing many authorities, and among other things it said: "In the ——— "edition of my work on ——— ——— ———, now in "press, the following is the language used by me upon "this subject, and the authorities supporting it are so "and so." So strong seemed the opinion given that the complainants, never doubting it would settle the case in their favor, printed it and used it as their brief upon the hearing. Unfortunately the case was decided against them.

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* Rhode Island Supreme Court, January, 1890 (decision not yet reported), Taggart *et al.* *v.* Newport Street Railway.

8 Ohio Circuit Court Reports, p. 425, Mt. Adams & Eden Park Inclined Plane Ry. Co. *v.* Howard Winslow *et als.*

Rocky Mountain Bell Tel. Co. *v.* Salt Lake City Street Railway Co. Not yet reported. Decided by Judge Zane.

Wisconsin Tel. Co. *v.* Eau Claire Street R'way, &c. Not yet reported. Decided by Judge Bundy.

East Tennessee Tel. Co. *v.* Knoxville Street R. R. Co. Decided by Chancellor Gibson. Not yet reported.

Cumberland Tel. & Tel. Co. *v.* United Elec. R'way Co., Circuit Court, U. S. Middle Dist. Tenn., 1890. Judge Brown.

Watervliet Turn. Co. *v.* Hudson R. Tel. Co., Court Appeals of N. Y. Albany, 1890.

Louisville Bagging Co. *v.* Cen. Pass. R'way Co. Decided by Judge Toney in Louisville Law & Equity Court, June 30, 1890. Not reported.

Pelton *v.* East Cleveland R. R. Co. In Circuit Court of Cuyahoga County, Ohio. Two decisions in 1890.

Tracy *v.* Troy & Lansingburg R. R., N. Y. Sup. Ct., 1890, at Albany.

Lonegrun *v.* Lafayette Street R'way. Circuit Court, Lafayette, Indiana. Judge Langdon, 1890.

A month or two later I read the account of a suit brought against a street railway in Philadelphia by a new-born infant through his guardian *ad litem*, for a severe jolting received on a street car by the plaintiff and his mother shortly before his birth, from which, as it was alleged, injuries had resulted and for which damages were claimed.

It occurred to me then that possibly the rough handling our great author and his unborn book received in the Newport case had caused him to insert something in his outcoming edition upon the subject of damages for embryonic injuries, which discussion had seemed to furnish the authority for this remarkable suit.

I sincerely hope the spirit of this pleasantry may not be misunderstood, for no one more highly esteems, honors, or venerates than myself the great judge, the eminent authority and splendid man, whose opinion in this case fared the fate which at times befalls those of every lawyer with a large practice.

Touching the cases in which the electric cars and the overhead structures were attacked as nuisances, this claim has also been uniformly overruled.

As to the charge made in many suits that the electric currents employed by street railways are dangerous to human life, the courts have uniformly found that the currents are not deadly. Indeed, they could not do otherwise, for the testimony was overwhelming. Not only was the theoretical testimony of all the leading experts given to the effect that the 450 to 500 volts as used by the railways is not deadly, but, by the testimony of many employees, it was shown that they had received the full shock of the electric current, in some instances repeatedly, without permanent injury; and notwithstanding many newspaper reports, I assert confidently that there is no instance on record of the death of a human being in America caused by the electric current used in street railway propulsion. With equal unanimity the courts have held the street railway electric currents not dangerous to property. The railway wires are strung throughout their entire length along the centre of the streets, nowhere approach the adjacent property, and are insulated even from their own supports and poles. It is true that these currents may be led off and conducted to adjacent property by improper contact with other bare and grounded wires which are allowed to fall upon or otherwise come in contact with them. There is not a lawyer in the United States representing insurance companies or insured property who is not deeply interested in this question. More danger arises to property from bare grounded telephone wires than from every other class of electric wires in the highway. It is true that the telephone wires have no considerable current of their own upon them. But there is the danger. For that reason the men engaged in constructing them neglect insulation, and they are often attached to combustible substances in buildings. Business men forget, or are often ignorant of the fact, that if these uncharged but bare and grounded wires in their buildings are permitted to come in contact with heavily charged wires which are on metallic circuits, the currents of electricity upon the heavily charged wires will leave their own circuits, come over the uncharged wire, in their search for earth, and thereby endanger the property to which the uncharged grounded wire is attached.

When we remember that telephone wires are invariably strung above, and cross and recross the street railway and electric light wires, the probability of damage to property is very apparent. The telephone wires are bare and grounded. A high wind or storm in the night has only to cause the telephone wire to swag or break and the contact with the charged wire below is established. Even if the electric light or railway wires be covered with insulation, a little rubbing back and forth as the wire is swayed by the wind, soon wears away the covering on the heavily charged wire, the dangerous current on the metallic circuit leaps to the *innocent* bare grounded telephone wire, the house which it enters is soon in flames, and no one can tell how the fire originated. It is the old story of death from the gun that we did not know was loaded. The telephones should invariably provide themselves, outside of buildings, with the device of "lightning arresters." This is a contrivance by which a break is made in the heavy wire of the telephone before it enters a building, and a short section of very fine wire is inserted. Theoretically, a heavy current coming onto a wire so provided, will burn up this section of fine wire, and thus break the continuity of wire and prevent the current entering the house. In point of fact, however, the current passes the point before the small wire is burnt up, or leaps across the breach, where the current is heavy. If the wires entering every building were compelled to enter and to leave it on a metallic circuit thoroughly insulated, and thorough insulation was observed around all instruments, the dangers adverted to would be avoided.

As the telephone wires and instruments are now constructed on grounded circuits and attached to any convenient conductors to the earth, they are, in my opinion, more dangerous to property than all the other electrical structures now erected.

Suits for personal injuries are, strange as the statement may at first seem, much less frequent with electric railways than with horse cars.

Much less space is occupied than when horses and cars covered so great a length of track. The track, and persons crossing it, are much more plainly seen by drivers than when the horses were in front of the driver. The cars, by cutting off current and applying brakes, are much more promptly stopped and reversed than with horses, and contrivances placed on the cars frequently throw persons falling in front of them off the tracks, who, with horse cars, would have been first trampled by the horses and then crushed.

The statistics show a marked diminution in this class of accidents upon the roads on which electricity has been introduced.

These, Mr. President and Gentlemen, are a few, and a very few, of the legal features of this newly introduced power.

I say a very few, for it is rapidly being introduced into every department of industry.

The divisibility of electric power is, perhaps, its surest guarantee of general introduction. In all applications of steam or other power heretofore known, even for the smallest uses considerable space and an extensive mechanical outfit has been necessary in the way of shafts, piping, belting, &c., upon the premises; and the power employed could never be transmitted to any great distance from the generating station.

Not so with electricity.

From a central generating station power may be conducted by a small wire to the point where it is to be used, in large quantities or in small quantities, according to the needs of the consumer.

As we pass from our homes to our work we step into a cigar store and light our cigar at an electric tip where the tiny current is just sufficient to make the spark. As we pass on we may see the workwoman sewing away upon her machine. She is no longer worn out with driving its treadle; a small current, introduced by a single wire through her window, sings for her now the "Song of the Shirt;" her task is light and cheerful. In the machine shops the heat and smoke and dirt of steam is fast disappearing, but the power is there, turned on or off by a contrivance no longer than a gas key. In the gaping foundations of our great buildings we hear the hissing grind of drills and the creaking of great hoists and derricks, but the puff of steam and belching smoke is gone. Turn to the mines. Electric fans keep the air pure; electric elevators in the shafts run noiselessly up and down; electric lights illuminate them throughout; electric tramways carry their products back and forth from the vein to the mouth. Animals in the pit no longer pollute the scant air or poison it with their breathing—it is no longer heated by the fires of machinery in the mine. All these things, above described, are accomplished from a station outside the mine, the same station, perhaps, that lit the cigar, ran the sewing machine, the drills, the hoists, &c., of other enterprises.

One more example and I have done:

Let us consider what may be accomplished by electricity applied to marine architecture. I fancy there are few present who know what a huge leviathan is one of our modern war vessels. So ponderous are their equipment and machinery that the mere propelling engines of an ironclad are but a small part of the power necessarily employed. In vessels of the larger class as many as sixty auxiliary engines, located in different parts of the ship, are employed for ventilating, heating, lighting, hoisting, elevating and depressing her guns, handling ammunition, &c., &c. The space occupied by these engines and the steam piping leading to and from them is very great, and the resulting heat from the fires and piping in such ships has been a source of infinite discomfort. But this is not all. Every shell that strikes a vessel thus equipped is not only likely to destroy the piping of one or more of her auxiliary engines and thereby to disable it, but to cause death and disorder from escaping steam. The time is not far distant when one electric plant, deep in the hold of a man-of-war, will furnish the power of every auxiliary engine in the hull. A shell may then crash through the vessel without doing further damage than the breaking of a wire which the armorer can reunite in a minute of time.

But why multiply instances?

One by one the industries cry out for this new found giant. The branches of industry in which it is employed are rapidly multiplying until they are already numbered by hundreds.

Not only does it revolutionize our *knowledge* of power but our very *conception* of it also. Time was when the ponderous wheel, the thundering crank, the creaking, jointed, levered mass was necessary to our every conception of mechanical force. Time is when we see the power which drives a heavy car, freighted to fullest capacity with human beings, up a ten per cent. grade, transmitted silently through a bit of wire not larger than, and not unlike, the wire shoe-buttoner I hold in my hand. Verily, amid such wonders may it not be, seeing how weak or how strong, how fierce yet how docile is this prodigy of electric power, that this it was which was foretold when the prophecy was made: "The lion and the lamb shall lie down together and a little child shall lead them."

These, Mr. President and Gentlemen, are but flitting glimpses of that which henceforth is to play a great part, greater than we yet know, in the development of future civilization.

No lawyer can foresee or realize how great an advantage to him will be a general comprehension of this subject. He does not know how suddenly he may be called upon to act, or for advice requiring a reasonable knowledge on his part of the subject, or how rapidly such knowledge is becoming not only a valuable adjunct, but a necessity of his business. Nor can he appreciate, until he has studied it, how charming a line of investigation lies unexplored before him.

Mr. Chairman, Gentlemen and Ladies, how shall I thank you for the courteous patience which has been so long suffering and meek though all this time I have detained you? I cannot and will not attempt it.

Yet I must, through you, convey to the State Bar Association my profound appreciation of the honor they have bestowed upon me in permitting me to address them. Had I been born in New York it would have been no compliment to her that I live here. Having been born elsewhere, it may still be a question whether my residence here is a compliment to her, but, so far as I am concerned I am not in default in tender. Certainly in my narrow range of vision and ambition I desire no higher honor than to be esteemed an humble but reputable attorney of the New York Bar. It is no disloyalty to my mother State, Virginia, thus to speak. On the jeweled breast-plate of judgment, worn by the Levitical high priests and lawgivers, two jewels shone afar, and excelling all others in brilliancy and lustre. In American jurisprudence, amid the glittering gems which adorn it, the great legal names and thoughts emanating from my mother State and the peerless land of my adoption, furnish two lights which gleam upon my loving and it may be unenlightened vision, with the bright, unequaled splendor of Urim and Thummim to the eyes of the worshipping Levite.

If at times even the partial eyes of a Virginian must see the tremor and waning light of her glory, I may yet take comfort from the thought that the star of my new-made home is waxing stronger and brighter as the years roll by.

The business heart and brain of America is not far distant, I think, from the capital of New York State. As in God's noblest creature, man, the brain, and through it the circulation, is moved by the optic nerve, so the Bar of New York, more than it perhaps knows, stands as guide and monitor of American business.

And as, in the human form divine, a pure transparent substance shields that optic nerve, protecting it and at the same time purifying, concentrating and truthfully transmitting to it all impressions it is to receive, so stands the New York State Bar Association in its relation to our Bar.

What higher function could any body of men possess?

To have been thought worthy to address such an assemblage, is an honor and a compliment of which any man may be proud. But, bestowed as it is upon me, almost a stranger and unworthy, as I know myself to be, of such high confidence, I forget the vanity which such preference begets, in my surprise and delighted admiration of this generous welcome of the stranger, found in New York as nowhere else on earth, which is one of the great secrets of her matchless Empire.

The Edison

Electric Light.

The Legal and

Commercial Status.

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EXECUTIVE OFFICES

THE EDISON ELECTRIC LIGHT CO.

16 AND 18 BROAD STREET,

NEW YORK, OCTOBER 7TH, 1886.

TO WHOM IT MAY CONCERN :

Your attention is respectfully solicited to the following facts. They are submitted not in a spirit of menace or as a threat, but simply as a matter of abstract justice both to shareholders, whom we represent, and to yourselves, as parties to whom our true position has been persistently misrepresented.

The fact that Mr. Thomas A. Edison invented the incandescent lamp in the form in which it is now presented by all electric light companies was so widely proclaimed by the publication thereof in every class of literature at the time of the invention, that it would now seem very like an insult to the intelligence of the community to recall it. Indeed, a retrospective view of the history of the great invention is rendered unnecessary by the fact that even the infringing companies themselves do not dwell upon their claim to the ownership of original patents, but fortify their position by the assertion that Edison's patents are invalid and open to the public, and offer in corroboration of their statement the apparent apathy of the Edison Company in the matter of defending them. That they, or doubtless many of them, are honest in their belief, and therefore in their representations, may be conceded without prejudice to the facts. In this way alone can be explained the business policy pursued by them of risking large private fortunes as well as the property of the shareholders of their respective companies in the form of guarantees against any damages the Edison Company may ultimately obtain from them or their customers for infringement of its patents.

It may very properly be asked does not the lapse of several years without the Edison suits appearing in the open Courts confirm the charge of apathy and prove the claim of invalidity? The Edison Company answers NO. They had reasons which restrained them from active patent litigation at the start, but that activity was ordered over a year ago, and in consequence of it more than 100 suits are now pending. Many of these, necessarily the most important thereof, will, in the natural order of legal procedure, reach trial within the coming year. Quiet preparation, together with important work done abroad, will ensure the rapid progress of these suits through the Courts the coming winter, and, to the end that no false steps shall be taken, additional counsel of the highest ability have lately been retained by the Edison Company.

Understanding that you are using, or are contemplating using, incandescent electric light based upon Mr. Edison's inventions, and in conformity with the spirit and essence of the above, your attention is called to the following statement showing what are the patents owned by the Edison Company.

We present also in the enclosed folder statistics showing the extent of the business done by the Edison Company under these patents. In contrast with the detailed statement therein submitted, we need only state that carefully compiled statistics show that the fifteen infringing companies, aspiring to secure business, by the illegal use of our patents, had up to the 1st day of October, 1886, placed in central stations and isolated plants throughout the U. S., a total of only 84,600 lamps. This includes a great number of lights now discontinued, and also several thousand lights yet to be supplied from central stations which were at that date in process of construction.

We are legally advised that we may look to you for damages in case we maintain any one of the broad patents enumerated herein. The measure of damages for infringement of patented goods has been fixed by the Courts at about three times the loss sustained by the owners thereof. The extent of the damage to the Edison Company may, in a degree, be approximated by a retrospective glance at the number and formidable character of the companies now embarked in the business of electric lighting, and therefore directly detracting from profits legally the right of the Edison Company.

For the purpose of enabling you to estimate your liability in the event of the Edison patents being sustained, we may state that a conservative calculation apportions a damage of $25 for each lamp in an original installation, and $2.50 for each renewal lamp, independent of the fact that such decision would necessarily render your plant inoperative.

As to the probability of such decision, you are reminded of the well established fact of the origin of the incandescent lamp, of the furore created at the time by the announcement of its discovery, and of the pilgrimage of thousands to Menlo Park to witness the exhibition made by Mr. Edison. You are further reminded of the fact that the Edison patents have been fully sustained in Germany and in England, in both of which countries a most exhaustive search utterly failed to develop either a lack of novelty or a structural weakness in the patent itself,—the two great rocks upon which most inventors' ships are stranded. You are further reminded of the fact that the delay in reaching a decision does not impair its force when attained, a notable example of which is the Goodyear Rubber Co., whose suits were not finally settled until after the expiration of the patents, when large amounts of money were collected in damages.

In respect to the value of the guarantees so freely given you by the companies themselves and by private individuals interested therein, we would respectfully inquire whether in your judgment either the corporations themselves or the individuals interested therein would be able to protect you from the avalanche of damages that the very multiplication of their business transactions during a long continued period of immunity would bring about them? In point of fact, does it not go without saying that the greater the extent to which they may exploit their business, the more disastrous will be the weakness of their guarantees when the day of settlement comes

In respect to the Patent suits brought against the Edison Co., attention is called to the imperative necessity the opposing companies were under to do something to break the moral force of the fact of the Edison suits—to the minor and even trifling details involved and generally to the fact that whilst the Edison Patents cover broadly the fundamental principles of incandescent lighting, the Edison Company does not pretend that the experience of others will not suggest to them more or less of improvement in detail. You are simply reminded in this respect that the Edison Co. being the first in the field and their work being upon such an extensive scale, they have necessarily had the larger experience and consequently their detail must possess the dual quality of originality and superior fitness. But, be this as it may, no detail patent has the force to either mulct a user in damages or stop his plant.

Trusting that our presentation of this purely business matter in a business way and in a spirit the reverse of hostile, may fully accord with your sense of justice and fair dealing, we beg to remain,

Very respectfully,
THE EDISON ELECTRIC LIGHT COMPANY,
E. H. JOHNSON,
President.

Description of the Edison Lamp.

The Edison Incandescent Electric Lamp consists of a chamber or receiver made entirely of glass, from which the air has been exhausted as completely as possible. This chamber is composed of two parts, a bulb or globe and an inner stem or tube; these parts are united by the fusing together of the glass. Through the inner stem pass two wires, and to the ends of these wires within the globe are attached the ends of the incandescent conductor. This is a filament of carbon of high electrical resistance. The ends of the filament are connected to the wires by electro-plating the joints with copper. The portion of each wire which passes through the end of the stem is of platinum, and at this part the glass is melted around the wires and the stem is pressed down upon them so as to form a flat seal. The lamp globe has at its lower end a base composed of plaster-of-paris upon which are secured two contact-plates, one of which is a screw-threaded ring encircling the base, and the other a tip or button at the extremity of the base. Each of the two wires leading from the carbon filament is connected to one of these contacts.

The lower end of the globe is irregular in shape, that is, it has projections extending from it into the plaster. This prevents the lamp from turning in its base.

In making the lamp the globe is first blown from the molten or pot glass; the wires are laid in the stem or tube, the end of the stem is pressed down upon them and the carbon filament is attached to them. This filament is made from a thin strip of bamboo fibre which is bent into the form of an arch or loop and then carbonized. The globe is then secured by fusion to the stem which has an enlargement or shoulder for this purpose. The lamp is then exhausted of air from the top of the globe, and sealed by fusing the glass together at that point.

While the lamp is being exhausted a current of electricity is passed through the filament, which heats it, and thus drives out the air and other gases which are contained in the pores of the carbon. After the lamp is sealed the base and contact-plates are placed upon it.

For each lamp is provided a socket or holder, so arranged that the lamp can be readily placed in or removed from it; it has within it two contact-plates placed so as to correspond with the contact-plates on the base of the lamp. The socket is adapted to be placed upon a fixture or any other suitable support, and the wires which are to convey current to the lamp enter the socket, and are connected with the contact-plates within it, so that when the lamp is placed in the socket the electrical circuit is completed to and from the carbon filament. The socket is provided with a key or circuit-controller, by turning which one side of the circuit is broken or closed, whereby the lamp is extinguished or lighted.

The following is a statement of certain of the patents owned by The Edison Electric Light Company, the features included in which are employed in the manufacture of the Edison lamp as described above and as shown in the cut, Figure 1, and also in lamps made by other manufacturers of incandescent electric lamps as shown in the other cuts:

1. Patent Number 223,898, dated January 27th, 1880, is for

"1. An electric lamp for giving light by incandescence, consisting of a filament of carbon of high resistance secured to metallic wires.

"2. The combination of carbon filaments with a receiver made entirely of glass, and conductors passing through the glass, and from which receiver the air is exhausted."

2. Patent Number 227,229, dated May 4, 1880, is for

"In an electric lamp, the combination with a hermetically sealed vacuum chamber made entirely of glass, of metallic conductors passing through the glass and around which the glass is melted, and an incandescent conductor placed in the electric circuit."

3. Patent Number 230,255, dated July 20th, 1880, is for

"The method of forming electric lamps, consisting in separately forming the inclosing globe and the supporting bulb for the incandescent conductor, attaching the wires and incandescent conductor thereto, and then hermetically uniting the parts prior to the formation of the vacuum."

4. Patent Number 251,540, dated December 27, 1881, is for

"An incandescing carbon conductor for electric lights, made from cane bamboo or similar fibre."

5. Patent Number 251,554, dated December 27, 1881, is for

"1. The combination with an incandescent electric lamp and its socket detachable from each other, and adapted to be used in a complete or round wire circuit, of controllable means for positively holding them in position together, and means for automatically completing the circuit connections between them through both limbs or members of the circuit upon placing them together in position.

"2. An incandescent electric lamp having contact-plates or rings upon its neck or base arranged one above the other on the base of the lamp forming the terminals of both limbs or members of a complete or round wire circuit.

"3. The combination with a separate removal incandescent electric lamp and its socket of means for holding them positively in position relatively to each other."

6. Patent Number 264,698, dated September 19, 1882, is for

"1. In an incandescent electric lamp the central tube of support formed with a solid, flat portion at its upper extremity, through which the leading-in conductors pass and in which they are sealed.

"2. The method of sealing the leading-in conductors into the central tubular carbon support of an incandescing electric lamp, consisting in squeezing the open upper end of the tube upon such conductors and at the same time closing air-tight such end of the tube."

7. Patent Number 264,737, dated September 19, 1882, is for

"1. An incandescing electric lamp having an irregularly shaped neck in combination with a collar attached to said neck, and metallic terminals secured to said collar and connected with the leading-in wires of the lamp."

8. Patent Number 265,311, dated October 3, 1882, is for

"1. A separate electric lamp, consisting essentially of an enclosing globe made entirely of glass, and incandescing material secured therein, conductors leading thereto and sealed in the glass where they pass therethrough, and a base of insulating material in which the neck of the globe is secured, said base being provided with metallic contact-plates to which the conductors leading into the globes are secured at their outer ends.

"2. A socket for an electric lamp adapted to be placed upon a gas-pipe or other suitable support, and provided with contact-plates forming the terminals of an electric circuit.

"3. The combination with a bracket or chandelier arm, or other gas or hollow pipe, containing the wires of an electric circuit, of a socket or holder for an electric lamp adapted to be secured therein, and to receive and support the lamp, and provided with contact-plates forming the terminal of the wires of the electric circuit.

"4. A socket for an electric lamp adapted to be placed upon a gas-pipe or other suitable support, and provided with contact-plates forming the terminals of an electric circuit, and also provided with a circuit controller inserted in one branch of the circuit for controlling the circuit."

9. Patent Number 265,777, dated October 20, 1882, is for

"The method of treating the carbon filament of an incandescing electric lamp, consisting in raising such carbon filament to incandescence during the latter part of the process of exhausting the lamp globe, whereby the air and gas are driven from the carbon filament and the flexibility of the filament is increased."

10. Patent Number 266,447, dated October 24, 1882, is for

"The method of manufacturing incandescent electric lamps, consisting in forming the inclosing globe or bulb directly from molten or pot glass, forming separately the supporting tube or neck for the incandescent conductor, sealing therein the leading-in wires, attaching the carbon thereto and then hermetically uniting the parts by welding together prior to the exhaustion of the lamp."

11. Patent Number 317,631, dated May 12, 1885, is for

"In an incandescing electric lamp, the combination with the glass inclosing globe and the neck thereof, of contact-plates joined together and held upon the neck of the lamp by plastic material."

12. Patent No. 251,596, dated December 27th, 1881, is for

"In a socket for electric lamps, the combination, with interior insulating portions provided with circuit-connections, of exterior metal portions, forming a covering therefor."

The following named patents are some of those owned by The Edison Electric Light Company, the devices covered by which are not used by that company but are employed in lamps made by other electric lamp manufacturers:

1. Patent Number 239,153, dated March 22, 1881, is for

"The combination with the glass inclosing globe and incandescing conductor of an electric lamp, of a support hermetically sealed to the globe and supporting the carbons at a distance above the point of sealing."

2. Patent Number 307,029, dated October 21, 1884, is for

> "The process of forming flexible incandescing filaments for electric lamps, consisting in first forming a straight filament of carbonizable substance, then carbonizing the same and finally bending the flexible filament thus formed into the desired shape."

In addition to the patents above enumerated, which relate only to the lamp itself, the Edison Co. is the owner of other patents covering other details of lamp construction, and of various devices, such as dynamo-electric machines, meters, motors, regulators, etc., which are or may be required to form a complete and perfect system of electric lighting or distribution.

The following is a complete list of the Edison Company's patents:

No.	Date.			Title of Patent.
181,613	August	29,	1876.	Electric Lighting.
214,636	April	22,	1879.	Improvement in Electric Lights.
214,637	"	22,	"	" " Thermal Regulators.
218,166	August	5,	"	" " Magneto-electric Machines.
218,167	"	5,	"	" " Apparatus for Electric Lights.
218,866	"	26,	"	" " Electric Lighting Apparatus.
219,393	Sept.	9,	"	" " Dynamo-electric Machines.
219,628	"	16,	"	" " Electric Lights.
222,881	Dec.	23,	"	" " Magneto-electric Machines.
223,112	"	30,	"	Method for Measuring Electricity.
223,898	Jan.	27,	1880.	Electric Lamp.
224,329	Feb.	10,	"	Electric Lighting Apparatus.
227,226	May	4,	"	Safety-conductor for Electric Lights.
227,227	"	4	"	Electric Light.
227,228	"	4,	"	" "
227,229	"	4,	"	" "
228,617	June	8,	"	Brake for Electro-magnetic Motors.
230,255	July	20,	"	Method of Manufacturing Electric Lamps.
237,732	Feb.	15,	1881.	Electric Light.
238,868	March	15,	"	Manufacture of Carbons, Incandescent Lamps.
239,147	"	22,	"	System of Electric Lighting.
239,148	"	22,	"	Treating Carbons for Electric Lamps.
239,149	"	22,	"	Incandescing Electric Lamp.
239,150	"	22,	"	Electric Lamp.
239,151	"	22,	"	Method of Forming Enlarged Ends on Carbon Filaments.
239,152	"	22,	"	System of Electric Lighting.
239,153	"	22,	"	Electric Lamp.
239,372	"	29,	"	Testing Electric Light Carbons.
239,373	"	29,	"	Electric Lamp.
239,374	"	29,	"	Regulating the Generation of Electric Currents.
239,745	April	5,	"	Electric Lamp.
240,678	"	26,	"	Webermeter.
242,896	June	14,	"	Incandescent Electric Lamp.
242,897	"	14,	"	" " "

No.	Date.	Title of Patent.
242,898	June 14, 1881.	Magneto or Dynamo-electric Machine.
242,899	" 14, "	Electric Lighting.
242,900	" 14, "	Manufacturing Carbons for Electric Lamps.
242,901	" 14, "	Electric Meter.
248,416	Oct. 18, "	Manufacture of Carbons for Electric Lamps.
248,417	" 18, "	Manufacturing " " " "
248,418	" 18, "	Electric Lamp.
248,419	" 18, "	Electric Lamp.
248,420	" 18, "	Fixture and Attachment for Electric Lamp.
248,421	" 18, "	Current Regulator for Dynamo-electric Machines.
248,422	" 18, "	System of Electric Lighting.
248,423	" 18, "	Carbonizer.
248,424	" 18, "	Fitting and Fixture for Electric Lamps.
248,425	" 18, "	Apparatus for Producing High Vacuums.
248,426	" 18, "	Apparatus for Treating Carbons.
248,427	" 18, "	Apparatus for Treating Carbons.
248,428	" 18, "	Manufacture of Incandescent Electric Lamps.
248,429	" 18, "	Electric Motor.
248,430	" 18, "	Electro-magnetic Brake.
248,433	" 18, "	Vacuum Apparatus.
248,434	" 18, "	Governor for Electric Engines.
248,435	" 18, "	Utilizing Electricity as a Motive Power.
248,436	" 18, "	Depositing Cell for Plating the Connections of Electric Lamps.
248,437	" 18, "	Apparatus for Treating Carbons.
248,565	" 18, "	Meter.
251,536	Dec. 27, "	Vacuum Pump.
251,537	" 27, "	Dynamo-electric Machine.
251,538	" 27, "	Electric Light.
251,539	" 27, "	Electric Lamp.
251,540	" 27, "	Carbon for Electric Lamps.
251,541	" 27, "	Electro-magnetic Motor.
251,542	" 27, "	System of Electric Lighting.
251,543	" 27, "	Electric Lamp.
251,544	" 27, "	Manufacture of Electric Lamps.
251,545	" 27, "	Electric Meter.
251,546	" 27, "	Electric Lamps.
251,547	" 27, "	Electric Governor.
251,548	" 27, "	Incandescent Electric Lamp.
251,549	" 27, "	Electric Lamp and the Manufacture thereof.
251,550	" 27, "	Magneto or Dynamo-electric Machine.
251,551	" 27, "	System of Electric Lighting.
251,552	" 27, "	Underground Conductor.
251,553	" 27, "	Electric Chandelier.
251,554	" 27, "	Electric Lamp and Socket.
251,555	" 27, "	Regulator for Dynamo-electric Machine.
251,556	" 27, "	Regulator for Dynamo-electric Machine.
251,557	" 27, "	Webermeter.
251,558	" 27, "	"
251,559	" 27, "	Electrical Drop-light.
251,596	" 27, "	Socket for Electric Lamps.
257,276	May 2, 1882.	Switch for Electric Light Circuits.
257,277	" 2, "	Socket for Electric Lamps.
260,562	July 24, "	Switch and Indicator for Electric Lamps.
12,631	" 27, "	Design for an Incandescent Electric Lamp.
263,133	August 22, "	Dynamo or Magneto-electric Machine.
263,134	" 22, "	Regulator for Dynamo or Magneto-electric Machines.
263,135	" 22, "	Electric Lamp.

No.	Date.	Title of Patent.
263,136	August 22, 1882.	Regulator for Dynamo or Magneto-electric Machines.
263,137	" 22, "	Electric Chandelier.
263,138	" 22, "	Electric Arc Light.
263,139	" 22, "	Manufacture of Carbons for Electric Lamps.
263,140	" 22, "	Dynamo-electric Machine.
263,141	" 22, "	Straightening Carbons of Electric Incandescent Lamps.
263,142	" 22, "	Electrical Distribution System.
263,143	" 22, "	Magneto or Dynamo-electric Machine.
263,144	" 22, "	Mold for Carbonizing Incandescents.
263,145	" 22, "	Making Incandescents.
263,146	" 22, "	Dynamo or Magneto-electric Machines.
263,147	" 22, "	Vacuum Apparatus.
263,148	" 22, "	Dynamo or Magneto-electric Machine.
263,149	" 22, "	Commutator for Dynamo or Magneto-electric Machines.
263,150	" 22, "	Magneto or Dynamo-electric Machine.
263,878	Sept. 5, "	Electric Lamps.
264,298	" 12, "	Coupling Device for Electrical Conductors.
264,299	" 12, "	Connection for Electric Circuits.
264,642	" 19, "	Electric Distribution and Translation System.
264,643	" 19, "	Magneto-electric Machine.
264,645	" 19, "	System of Conductors for the Distribution of Electricity.
264,646	" 19, "	Dynamo or Magneto-electric Machine.
264,647	" 19, "	Dynamo or Magneto-electric Machine.
264,648	" 19, "	Dynamo or Magneto-electric Machine.
264,649	" 19, "	Dynamo or Magneto-electric Machine.
264,650	" 19, "	Manufacture of Incandescing Electric Lamps.
264,651	" 19, "	Incandescent Electric Lamp.
264,652	" 19, "	Incandescent Electric Lamp.
264,653	" 19, "	Incandescent Electric Lamp.
264,654	" 19, "	Incandescent Electric Lamp.
264,655	" 19, "	Incandescent Electric Lamp.
264,656	" 19, "	Incandescent Electric Lamp.
264,657	" 19, "	Incandescent Electric Lamp.
264,658	" 19, "	Regulator for Dynamo-electric Machines.
264,659	" 19, "	Regulator for Dynamo-electric Machines.
264,660	" 19, "	Regulator for Dynamo-electric Machines.
264,661	" 19, "	Regulator for Dynamo-electric Machines.
264,662	" 19, "	Regulator for Dynamo-electric Machines.
264,663	" 19, "	Regulator for Dynamo-electric Machines.
264,664	" 19, "	Regulator for Dynamo-electric Machines.
264,665	" 19, "	Regulator for Dynamo-electric Machines.
264,666	" 19, "	Regulator for Dynamo-electric Machines.
264,667	" 19, "	Regulator for Dynamo-electric Machines.
264,668	" 19, "	Regulator for Dynamo-electric Machines.
264,669	" 19, "	Regulator for Dynamo-electric Machines.
264,670	" 19, "	Regulator for Dynamo-electric Machines.
264,671	" 19, "	Regulator for Dynamo-electric Machines.
264,672	" 19, "	Regulator for Dynamo-electric Machines.
264,673	" 19, "	Regulator for Dynamo-electric Machines.
264,698	" 19, "	Electric Lamp.
264,737	" 19, "	Incandescing Electric Lamp.
265,311	Oct. 3, "	Electric Lamps and Holders for Same.
265,774	" 10, "	Maintaining Temperature in Webermeters.
265,775	" 10, "	Electric Arc Light.
265,776	" 10, "	Electric Lighting System.
265,777	" 10, "	Treating Carbons for Electric Lamps.

No.	Date.	Title of Patent.
265,779	Oct. 10, 1882.	Regulator for Dynamo-electric Machines.
265,780	" 10, "	Regulator for Dynamo-electric Machines.
265.781	" 10, "	Regulator for Dynamo-electric Machines.
265,782	" 10, "	Regulator for Dynamo-electric Machines.
265,783	" 10, "	Regulator for Dynamo-electric Machines.
265,784	" 10, "	Regulator for Dynamo-electric Machines.
265,785	" 10, "	Dynamo-electric Machine.
265,786	" 10, "	Apparatus for the Electrical Transmission of Power.
265,858	" 10, "	Regulator for Dynamo-electric Machines.
265,859	" 10, "	Regulator for Dynamo-electric Machines.
266,447	" 24, "	Electric Incandescent Lamps.
266,588	" 24, "	Vacuum Apparatus.
266,793	" 31, "	Electrical Distribution Systems.
266,808	" 31, "	Safety-catch.
268,205	Nov. 28, "	Dynamo or Magneto-electric Machines.
268,206	" 28, "	Incandescing Electric Lamps.
271,613	Feb. 6, 1883.	Manufacture of Incandescing Electric Lamps.
271,614	" 6, "	Shafting.
271,615	" 6, "	Governors for Dynamo-electric Machines.
271,616	" 6, "	Regulators for Dynamo-electric Machines.
271,628	" 6, "	Secondary Batteries.
271,654	" 6, "	Regulators for Dynamo-electric Machines.
273,485	March 6, "	Incandescing Electric Lamps.
273,486	" 6, "	Incandescing Electric Lamps.
273,487	" 6, "	Regulators for Dynamo-electric Machines.
273,488	" 6, "	Regulators for Dynamo-electric Machines.
273,491	" 6, "	Regulators for Driving Engines of Electrical Generators.
273,492	" 6, "	Secondary Batteries.
273,493	" 6, "	Valve-gear for Electrical Generator-engines.
273,828	" 13, "	System of Underground Conductors for Electrical Distribution.
274,290	" 20, "	Systems of Electrical Distribution.
274,291	" 20, "	Molds for Carbonizing.
274,292	March 20, 1883.	Secondary Batteries.
274,293	" 20, "	Electric Lamps.
274,294	" 20, "	Incandescing Electric Lamps.
274,295	" 20, "	Incandescing Electric Lamps.
274,296	" 20, "	The Manufacture of Incandescents.
275,612	April 10, "	Manufacture of Incandescing Electric Lamps.
275,613	" 10, "	Incandescing Electric Lamps.
275,749	" 10, "	Connection for Electric Light Fixtures.
276,232	" 24, "	Means for Operating and Regulating Electrical Generators.
276,233	" 24, "	Electrical Generators and Motors.
13,940	May 29, "	Design for Incandescing Electric Lamps.
278,413	" 29, "	Regulator for Dynamo-electric Machine.
278,414	" 29, "	Regulator for Dynamo-electric Machine.
278,415	" 29, "	Manufacturing of Incandescing Electric Lamps.
278,416	" 29, "	Manufacturing of Incandescing Electric Lamps.
278,417	" 29, "	Manufacturing of Incandescing Electric Lamps.
278,418	" 29, "	Apparatus for Translating Electric Currents from High to Low Tension.
278,419	" 29, "	Dynamo-electric Machine.
278,535	" 29, "	System of Electrical Distribution.
280,563	July 3, "	Electrical Measuring Apparatus.
280,727	" 3, "	System of Electrical Distribution.
281,349	" 17, "	Regulator for Dynamo-electric Machines.
281,350	" 17, "	Regulator for Dynamo-electric Machines.

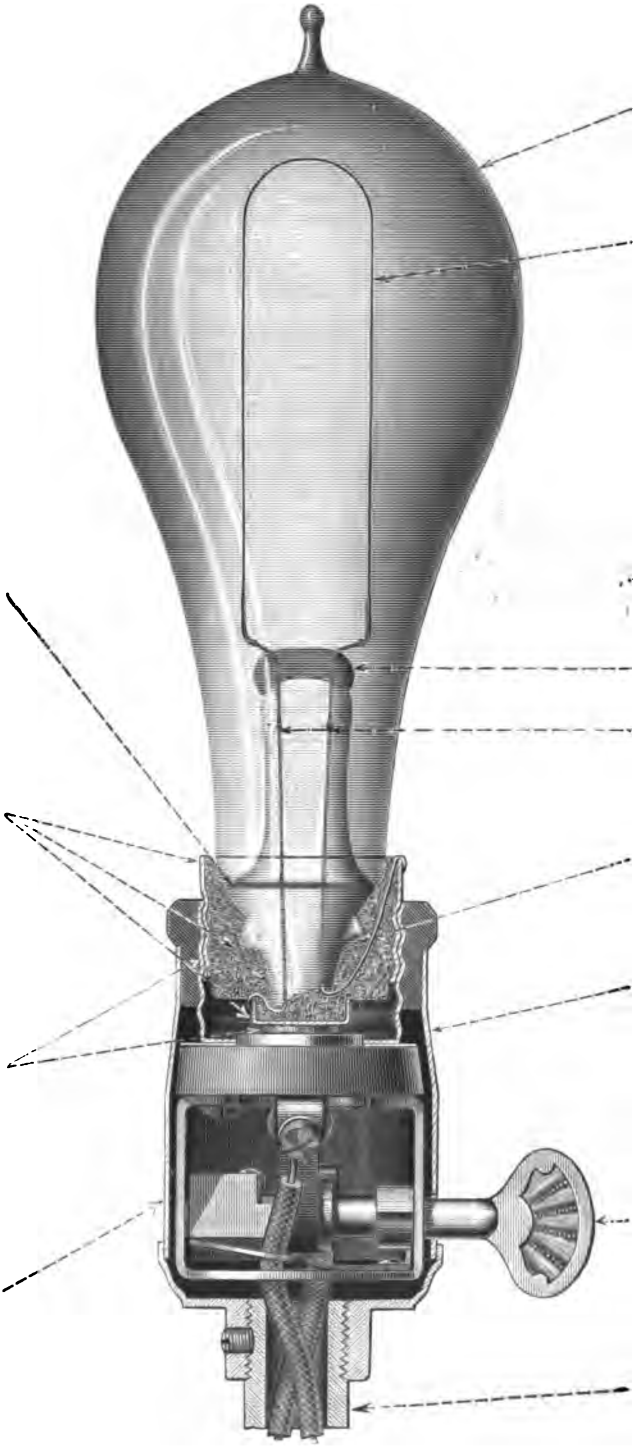
No.	Date.			Title of Patent.
281,351	July	17,	1883.	Electrical Generator.
281,352	“	17,	“	Webermeter.
281,353	“	17,	“	Dynamo-electric Machine.
281,576	“	17,	“	Safety-catch for Electric Light Circuits.
283,270	August	14,	“	Incandescing Electric Lamp.
283,983	“	28,	“	System of Electrical Distribution.
283,984	“	28,	“	System of Electrical Distribution.
283,985	“	28,	“	System of Electrical Distribution.
283,986	“	28,	“	System of Electrical Distribution.
287,501	Oct.	30,	“	Electrical Testing.
287,511	“	30,	“	Electric Regulator.
287,512	“	30,	“	Dynamo-electric Machine.
287,513	“	30,	“	Dynamo-electric Machine.
287,514	“	30,	“	Dynamo-electric Machine.
287,515	“	30,	“	System of Electrical Distribution.
287,516	“	30,	“	System of Electrical Distribution.
287,517	“	30,	“	System of Electrical Distribution.
287,518	“	30,	“	Manufacturing Incandescing Electric Lamps.
287,519	“	30,	“	Incandescing Electric Lamp.
287,520	“	30,	“	Incandescing Conductor for Electric Lamps.
287,521	“	30,	“	Dynamo-electric Machine.
287,522	“	30,	“	Mold for Carbonizing.
287,523	“	30,	“	Dynamo-electric Machine.
287,524	“	30,	“	Regulator for Dynamo-electric Machine.
287,525	“	30,	“	Regulator for Systems of Electric Distribution.
287,532	“	30,	“	Junction for Electrical Conductors.
287,533	“	30,	“	Safety-catch for Electric Circuits.
288,318	Nov.	13,	“	Regulator for Dynamo-electric Machine.
293,432	Feb.	12,	1884.	Electrical Generator or Motor.
293,434	“	12,	“	Incandescent Electric Lamp.
293,435	“	12,	“	Electrical Meter.
297,580	April	29,	“	Electric Arc Lights.
297,581	“	29,	“	Incandescent Electric Lamp.
297,582	“	29,	“	Dynamo-electric Machine.
297,583	“	29,	“	Dynamo-electric Machine.
297,584	“	29,	“	Dynamo-electric Machine.
297,585	“	29,	“	Incandescing Conductor for Electric Lamps.
297,586	“	29,	“	Electrical Conductor.
297,587	“	29,	“	Dynamo-electric Machine.
298,658	May	13,	“	Socket for Incandescent Electric Lamps.
298,679	“	13,	“	Treating Carbons for Electric Lights.
298,954	“	20,	“	Dynamo-electric Machine.
298,955	“	20,	“	Dynamo-electric Machine.
298,956	“	20,	“	Operating Dynamo-electric Machines.
304,082	August	26,	“	Electrical Meter.
304,083	“	26,	“	Dynamo-electric Machine.
304,084	“	26,	“	Device for Protecting Electric Light Systems from Lightning.
304,085	“	26,	“	System of Electrical Distribution.
304,086	“	26,	“	Incandescent Electric Lamp.
304,087	“	26,	“	Electrical Conductor.
307,029	Oct.	21,	“	Filament for Incandescent Lamps.
307,030	“	21,	“	Electrical Meter.
307,031	“	21.	“	Electrical Indicator.
314,582	March	21,	1885.	Safety-catch for Electric Circuits.
317,632	May	12,	“	Incandescent Electric Lamp.
317,633	“	12,	“	Incandescent Electric Lamp.
328,572	ct.	20,	“	Commutator for Dynamo Electric Machine.
328,573	“	20,	“	System of Electric Lighting.
328,574	“	20,	“	System of Electric Lighting.

No.	Date.		Title of Patent.
328,575	Oct.	20, 1885.	System of Electric Lighting.
334,853	Jan.	26, 1886.	Mold for Carbonizing.
339,279	April	6, "	System of Electric Distribution.
341,644	May	11, "	Incandescent Electric Lamp.
341,839	"	11, "	Incandescent Electric Lamp.

The following cuts are designed to illustrate the infringement of the Edison patents by the lamps of other makers. They are taken directly from the lamps and sockets themselves.

It will be apparent that in each of the infringing lamps, where it is attempted to avoid any one of the Edison patents, this is done by the omission of some useful part or device, or by the substitution of inferior ones to those employed by the Edison Company.

All lamps now on the market, it will be seen, infringe a greater or less number of the Edison patents, and it is impossible to construct a commercially practical incandescent electric lamp without using many of the devices covered by the patents owned by The Edison Electric Light Company.



Exhausted glass globe. Pat. 223,898 & 227,229. Blown from pot glass. Pat. 266,447.

High resistance carbon filament. Pat. 230,255; made of bamboo. Pat. 251,540; heated to incandescence while lamp was being exhausted. Pat. 265,777.

Point where two parts are joined by fusion. Pat. 230,255.

Flat seal. Pat. 264,698.

Wires sealed in glass. Pat. 223,898, 227,229.

Base of insulating material with two contacts upon it. Pat. 251,554, 265,311, 317,631, 264,787.

Irregularities in shape. Pat. 264,787.

Metal casing of socket. Pat. 251,596.

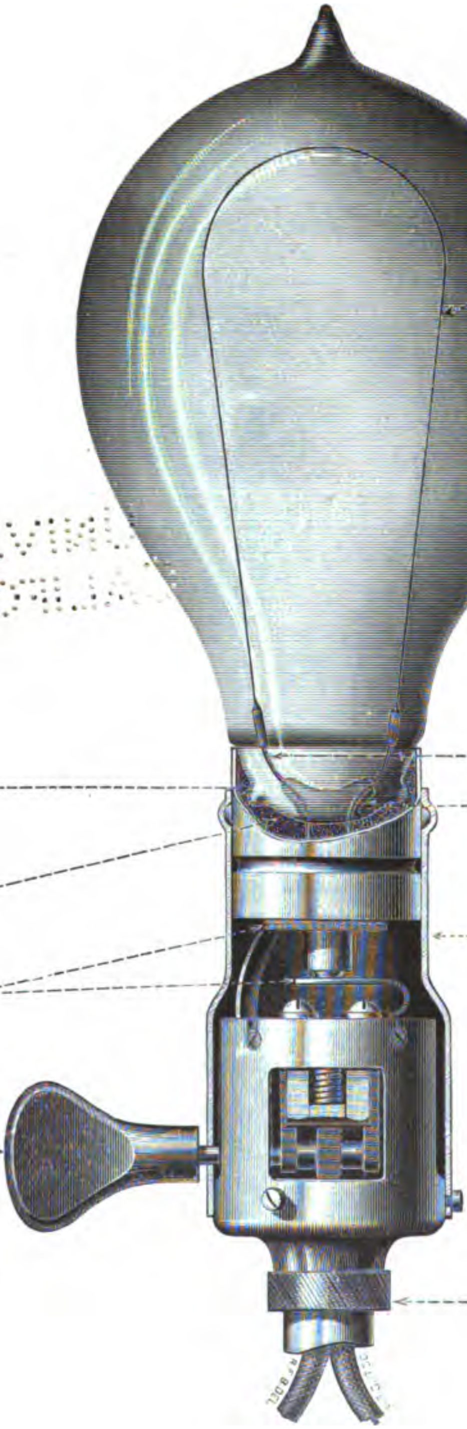
Screw threads to hold lamp and socket positively together. Pat. 251,554; socket contacts corresponding to lamp contacts. Pat. 251,554, 265,311.

Circuit controller. Pat 265,311.

Detachable socket. Pat. 251,554, 265,311.

Gas pipe or fixture arm. Pat. 265,311.

THE EDISON LAMP.



Exhausted glass globe. Edison Pats. 223,898, 227,229.

Blown from potglass. Edison Pat. 266,447.

High resistance carbon filament. Edison Pat. 230,255; heated to incandescence while lamp was being exhausted. Edison Pat. 265,777; filament formed straight, then carbonized and then bent. Edison Pat. 307,028.

Wires sealed in glass. Edison Pats. 223,898, 227,229.

Irregularities in shape. Edison Pat. 264,787.

Flat seal. Edison Pat. 264,698.

Base of insulating material with two contacts upon it. Edison Pats. 251,554, 265,311, 317,631, 264,787.

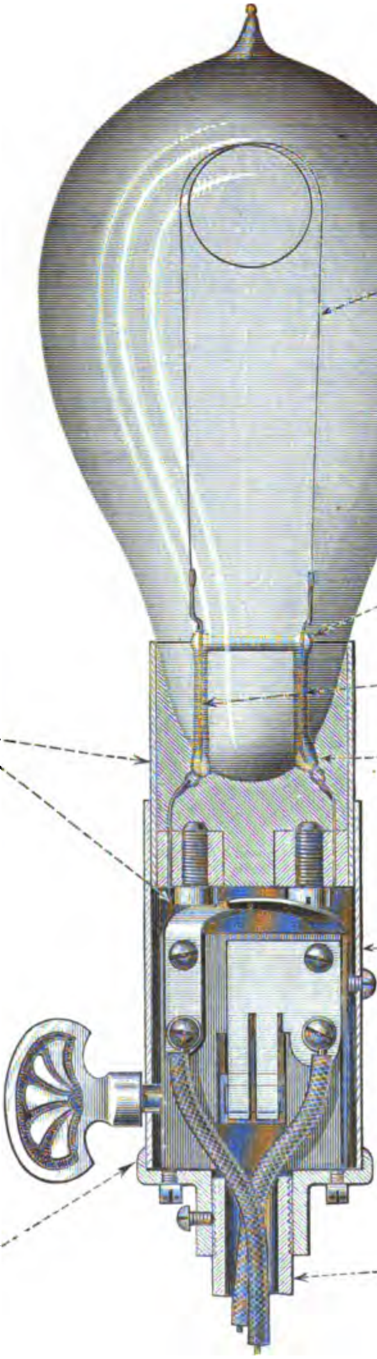
Detachable socket metal casing of socket. Edison Pat. 251,596.

Socket contacts corresponding to lamp contacts. Edison Pats. 251,554, 265,311.

Circuit controller. Edison Pat 265,311.

Gas pipe or fixture arm Edison Pat. 265,311.

The United States Co. (Weston Lamp) Infringing the Edison Patents.



Exhausted glass globe. Edison Pats. 223,898, 227,229. Blown from pot glass. Edison Pat. 266,447.

High resistance carbon filament. Edison Pat. 230,255. Heated to incandescence while lamp was being exhausted. Edison Pat. 265,777.

Flat seal. Edison Pat. 264,698: support above point of sealing. Edison Pat. 239,153.

Base of insulating material, with two contacts upon it. Edison Pats. 251,554, 265,311, 317,631, 264,737. Socket contacts corresponding to lamp contacts. Edison Pats. 251,554 265,311.

Wires sealed in glass. Edison Pats. 223,898, 227,229.

Irregularities in shape. Edison Pat. 264,787.

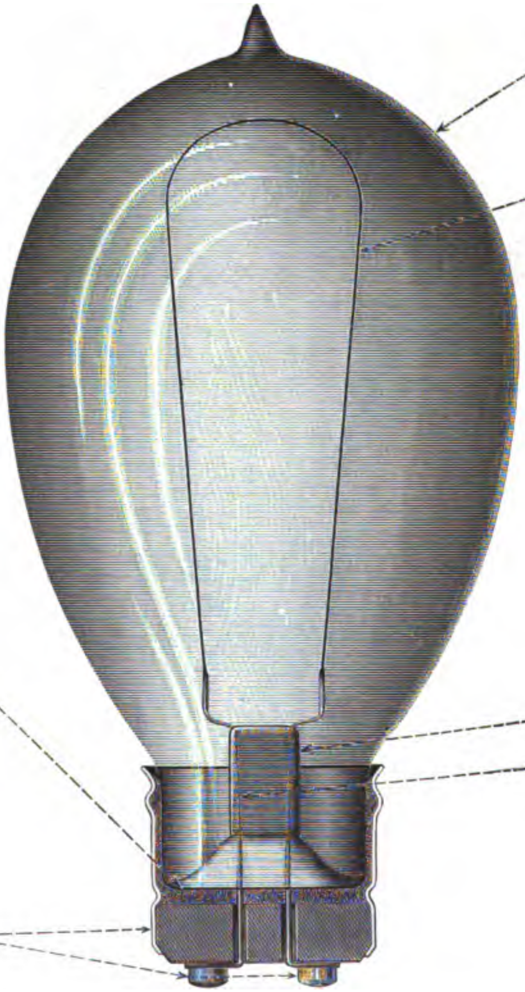
Metal casing of socket. Edison Pat. 251,596.

Circuit controller. Edison Pat. 265,311.

Detachable socket. Edison Pats. 251,554, 265,311.

Gas pipe or fixture arm. Edison Pat. 265,311.

Brush-Swan Infringements of the Edison Patents.



Exhausted glass globe. Edison Pats. 223,898, 227,229.

Blown from pot glass. Edison Pat. 266,447.

High resistance carbon filament. Edison Pat. 230,255.

Heated to incandescence while lamp is being exhausted. Edison Pat. 265,777.

Point where two parts are joined by fusion. Edison Pat. 230,255.

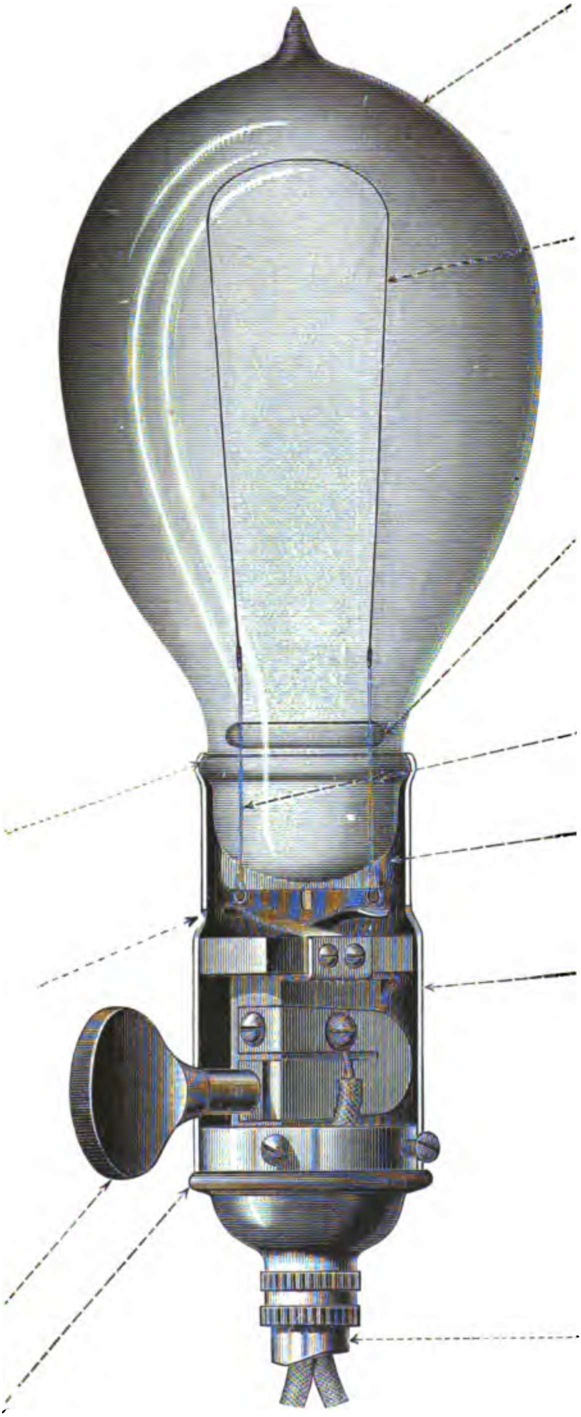
Flat seal. Edison Pat. 264,698.

Wires sealed in glass. Edison Pats. 223,898, 227,229.

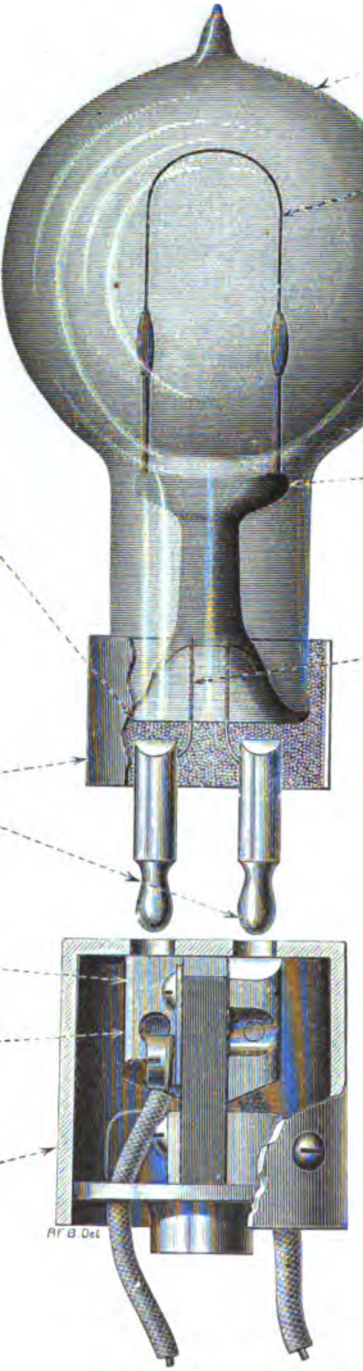
Socket contacts corresponding to lamp contacts. Edison Pats. 251,554, 265,311.

Base of insulating material, with two contacts upon it. Edison Pats. 251,554, 265,311, 317,631, 264,737.

Westinghouse Co. Infringements of the Edison Patents (No. 1).


Exhausted glass globe. Edison Pats. 223,898, 227,229. Blown from pot glass. Edison Pat. 266,447.
High resistance carbon filament. Edison Pat. 230,255. Heated to incandescence while lamp was being exhausted. Edison Pat. 265,777.
Flat seal. Edison Pat. 264,698; support above point of sealing. Edison Pat. 239,153.
Wires sealed in glass. Edison Pats. 223,898, 227,229.
Point where two parts are joined by fusion. Edison Pat. 230,255; means on socket for holding lamp and socket positively together. Edison Pat. 251,554.
Irregularities in shape. Edison Pat. 264,787.
Contacts on socket. Edison Pats. 251,554, 265,811.
Metal casing of socket. Edison Pat. 251,596.
Circuit controller. Edison Pat. 265,811.
Gas pipe or fixture arm. Edison Pat. 265,811.
Detachable socket. Edison Pats. 251,554 265,811.

Westinghouse Co. Infringements on the Edison Patents (No. 2).



Exhausted glass globe. Edison Pats. 223,898, 227,229. Blown from pot glass. Edison Pat. 266,-447.

High resistance carbon filament. Edison Pat. 230,255. Heated to incandescence while lamp was being exhausted. (Edison Pat. 265,777.

Point where two parts are joined by fusion. Edison Pat. 230,-225.

Flat seal. Edison Pat. 264,698.

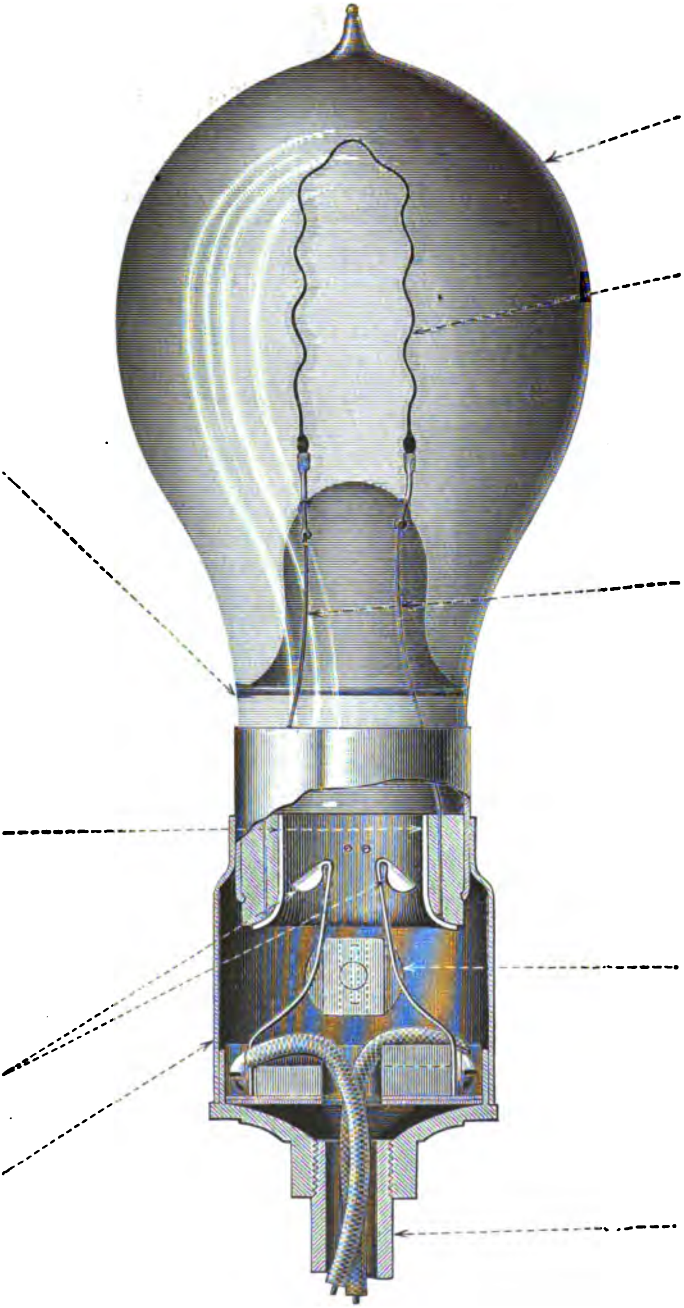
Wires sealed in glass. Edison Pats. 223,898, 227,-229.

Base of insulating material with two contacts upon it. Edison Pats. 251,-554, 265,311, 317,-611, 264,787.

Socket contacts corresponding to lamp contacts. Edison Pats. 251,554 265,-311.

Detachable socket. Edison Pats. 251,554, 265,-311.

Bernstein Infringements of the Edison Patents.



Exhausted glass globe. Edison Pats. 223,898, 227,229. Blown from pot glass. Edison Pat. 266,447.

High resistance carbon filament. Edison Pat. 230,255. Heated to incandescence while lamp was being exhausted. Edison Pat. 265,777.

Point where two parts are joined by fusion. Edison Pat. 230,255.

Wires sealed in glass. Edison Pats. 223,898, 227,229.

Base of insulating material with two contacts upon it. Edison Pats. 251,554, 265,311, 317,631, 264,787.

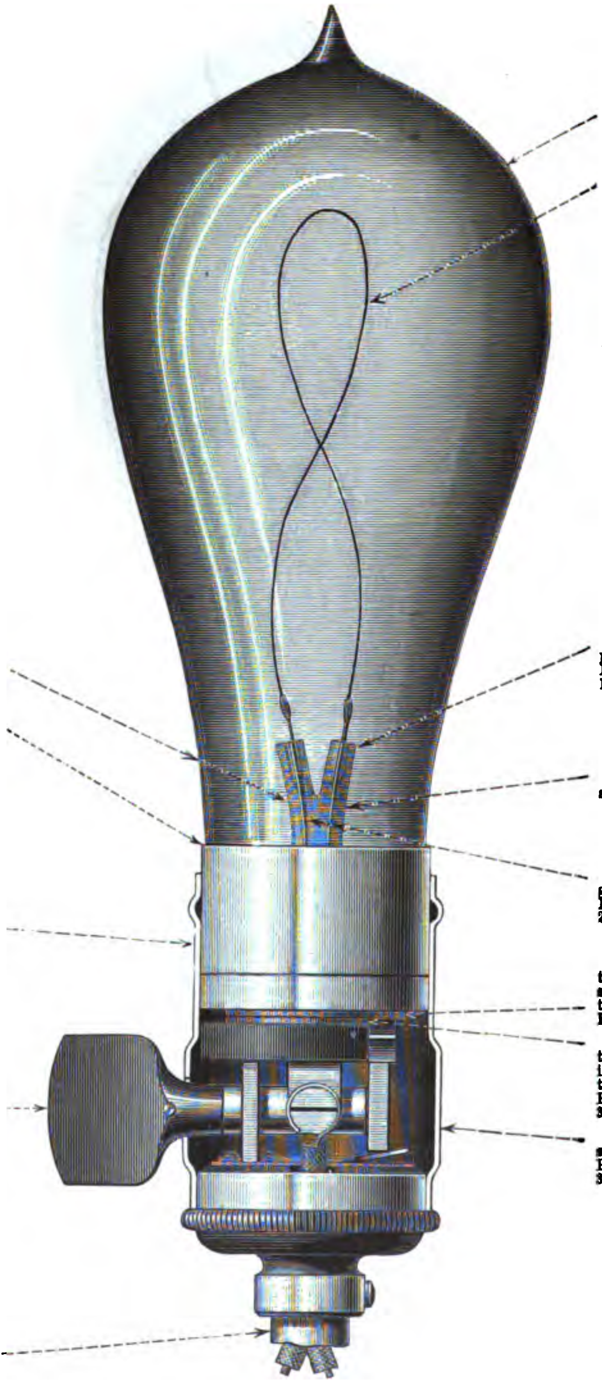
Circuit controller. Edison Pat. 265,311.

Socket contacts corresponding to lamp contacts. Edison Pats. 251,554, 265,311.

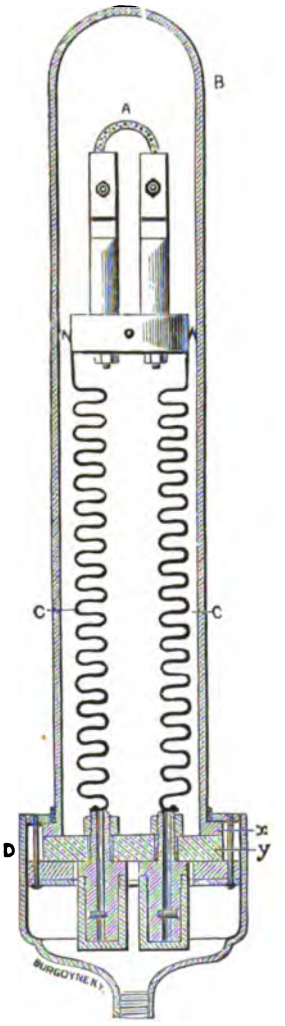
Detachable socket. Edison Pats. 251,554, 265,311.

Gas pipe or fixture arm. Edison Pat. 265,311.

Mather Co. Infringements on the Edison Patents.


Exhausted glass globe. Edison Pats. 223,898, 227,229.
High resistance carbon filament. Edison Pat. 230,255.
Made of bamboo. Edison Pat. 251,540.
Heated to incandescence while lamp was being exhausted. Edison Pat. 265,777.
Support above point of sealing. Edison Pat. 239,158.
Base of insulating material, with two contacts upon it. Edison Pats. 251,554, 265,311, 317,631, 264,737.
Flat seal. Edison Pat. 264,698.
Wires sealed in glass. Edison Pats. 223,898, 227,229.
Metal casing of socket. Edison Pat. 251,596.
Screw threads to hold lamp socket positively together. Edison Pat. 251,554.
Socket contacts corresponding to lamp contacts. Edison Pats. 251,554, 265,311.
Circuit controller. Edison Pat. 265,311.
Detachable socket. Edison Pats. 251,554, 265,311.
Gas pipe or fixture arm. Edison Pat. 265,311.

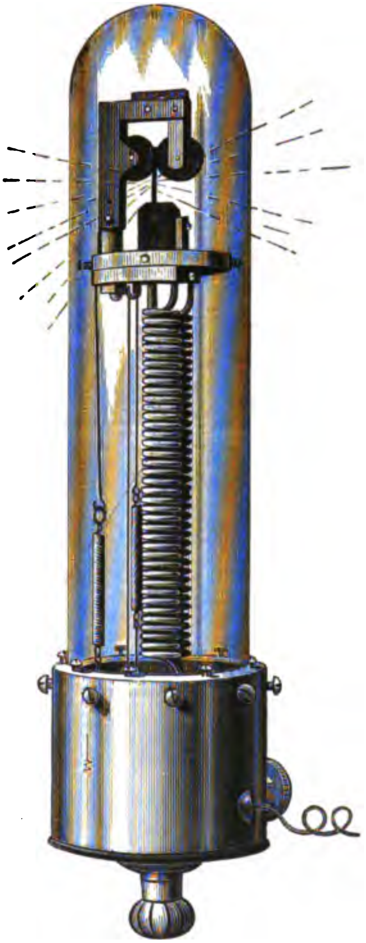
Consolidated Co. (Sawyer-Man) Infringements of the Edison Patents.



Sawyer-Man Lamp.

The Sawyer and Man Lamp, as patented by them May 12, 1885, the application for the patent having been filed January 9, 1880.

Referring to the letters on the illustration, A is a piece of carbon $\frac{1}{10}$ of an ohm in resistance; the globe B is filled with nitrogen gas, and has its base flange *x* clamped by rings and bolts to the plate *y;* the cup D is filled with wax; the conductors C C are known as "radiators," and serve to radiate the heat generated by waste of energy in the lamp.



Sawyer Lamp.

After the failure of Sawyer and Man, Sawyer alone produced what he called his "feeder" lamp, shown by this cut.

This lamp has the burner of the old Werdermann Lamp placed in a Sawyer and Man structure. Like the Sawyer and Man Lamp it was a failure.

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SECOND

ANNUAL REPORT

OF THE

EDISON GENERAL ELECTRIC COMPANY.

January 19, 1891.

TRUSTEES

OF THE

Edison General Electric Company,

OCTOBER 31st, 1890.

C. H. COSTER,
JOSEPH S. DECKER,
THOMAS A. EDISON,
J. H. HERRICK,
SAMUEL INSULL,
EDWARD H. JOHNSON,
A. MARCUS,
CARL SCHURZ,
FRANCIS S. SMITHERS,
HENRY VILLARD,
J. HOOD WRIGHT.

EXECUTIVE OFFICERS.

President,	HENRY VILLARD.
Vice-President,	J. H. HERRICK.
Second Vice-President,	SAMUEL INSULL.
Secretary,	A. MARCUS.
Treasurer and Assistant Secretary,	F. S. HASTINGS,
Assistant Treasurer,	A. S. BEVES.
Comptroller,	JOSEPH P. ORD.

OFFICE IN NEW YORK:

Edison Building, Broad Street.

Report of the Board of Trustees.

To the Stockholders of the
Edison General Electric Company:—

Before proceeding to consider the business of the past year and the prospects for the future, your Trustees desire to call your attention to the

Changes in the Organization and Management of the Company,

which formed an important incident in the record of its corporate year.

As set forth in the first annual report, the Company started out with the ownership of nearly all the stock of the Edison Electric Light Company; and all the stock of the companies owning the Works at Schenectady; the Works in New York City producing apparatus and fixtures; the Canadian Edison Manufacturing Company, and the Lamp Works at Harrison, New Jersey; also of the United Edison Manufacturing Company of New York, as the general selling agent for the United States; and also owning a large interest in the Sprague Electric Railway and Motor Company, of which Company the entire capital stock has since been acquired.

Each of these concerns was managed as a separate corporation, and the supervision of the business was thus very complicated and imperfect; and, in addition, the large and rapidly growing selling, contracting and constructing business extending all over the United States and Canada, was conducted through no less than twenty different companies and agencies, all having separate methods and accounts. It was found practically impossible to exercise over so many distinct organizations the close supervision necessary to secure rigid accountability and to conduct the business on an economical basis. It was found, further, that the prevailing system of allowing commissions on business obtained through local agencies was very expensive, without bringing adequate returns.

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Your Board therefore decided, after mature deliberation, to bring about a unification of all the allied manufacturing corporations and selling agencies, of which this Company owned or was able to acquire all the stock, by taking over their respective assets and liabilities, thus carrying out a practical consolidation of the corporations, and transferring to this Company the absolute ownership of all the property heretofore vested in them. It further determined that the entire business of manufacturing, selling and installing should be conducted in the General Company's own name, through its own employes.

The Edison Electric Light Company was excepted from this arrangement; and it remains an active, independent body in all respects.

The autonomy of the Sprague Company, which owns valuable patents, was also preserved, although all its other assets and liabilities have been taken over by the General Company.

The new organization went into effect on August 1st. The United States and Canada were divided into eight geographical Districts, each in charge of a District Manager, instructed by, reporting, and directly responsible to the Executive Officers of this Company. The Districts, with their headquarters, are as follows:

CANADIAN DISTRICT, - - -	Toronto.
CENTRAL DISTRICT, - - -	Chicago.
EASTERN DISTRICT, - - - -	New York.
NEW ENGLAND DISTRICT, - -	Boston.
PACIFIC COAST DISTRICT, - -	San Francisco.
PACIFIC NORTHWEST DISTRICT, - -	Portland, Oregon.
ROCKY MOUNTAIN DISTRICT, - -	Denver.
SOUTHERN DISTRICT, - - -	New Orleans.

It is already demonstrated that this consolidated organization is of great and growing advantage to the Company. Great credit for its inception is due to the Second Vice-President, Mr. SAMUEL INSULL, and to him and the Comptroller, Mr. JOSEPH P. ORD, jointly, for its execution.

FINANCIAL.

The expectation of an increase of business, expressed in the last annual report, was fulfilled much earlier and on a larger scale than was anticipated, and it became necessary to provide for a corresponding enlargement of our manufacturing plants and for additional working capital. For these purposes your Board disposed of the unissued capital stock of the Company; and the Sprague Electric Railway and Motor Co. borrowed $2,000,000, for the payment of which the lenders have agreed to take stock of the General Company.

A special meeting of the stockholders will be held immediately after the annual meeting, in order to consider and act on the recommendation of your Board that the capital stock of the Company be increased from twelve to fifteen millions. Two millions of this increase will be used in liquidation of the above mentioned loan, and the remaining one million reserved to meet future requirements.

As the net earnings of the past year exceed 8 per cent. on the total stock of the Company, the trust created under three certain agreements with the Farmers' Loan and Trust Company has reached its termination, and the stock heretofore held thereunder becomes entitled to rate equally in all respects with all other outstanding stock, and to participate in all dividends hereafter paid, including the 2% payable February 1st, 1891. The stockholders at their forthcoming annual meeting will, in accordance with notice already published, be asked to give consideration to this subject and to authorize the payment of the dividend on the trust stock, together with such other steps as are necessary to have the trust certificates issued by the Farmers' Loan and Trust Company exchanged for the actual stock.

THE BUSINESS OF THE COMPANY.

As an illustration of the magnitude of the business of the Company, it may be stated that there are about six thousand employes on its pay rolls, and that the transactions of the past year represented an aggregate of ten millions of dollars.

The new fiscal year opens with sufficient orders on hand, notwithstanding the enlargement of our manufacturing facilities, to keep the Works fully employed for the next six months; and there is every indication that their increased capacity will be taxed to the utmost throughout the year, as the public is beginning to realize more and more the great advantages and profits resulting from the application of electric light and power to domestic, industrial and transportation purposes.

In the special field in which none of our competitors approach us even remotely, viz., the distribution of light and power from large central stations, a great development is taking place. In New York City, a station, with a maximum capacity of 200,000 lights, the largest in this country, is being erected by the local Company, and new stations of large capacity are going up in Brooklyn, Chiçago, Milwaukee and Cincinnati.

The local Edison Companies obtain their entire electrical plant and additions thereto, including apparatus and fixtures of every kind, from our Works; and every new station therefore results in a large, new and ever-growing business.

According to the official record, there were in operation on November 1, 1890, within the territory of the United States and the Dominion of Canada, large and small Edison stations representing an aggregate capacity of 1,371,000 lamps.

In the Railway Department there was also greatly increased activity. The Sprague car motors sold in 1889–90 represent an aggregate of 27,679 horse-power, and the generators (dynamos for traction current) 22,836 horse-power, as compared with motors of 10,680 horse-power and generators of 7,665 horse-power in 1888–89.

It will not be out of place to mention in this connection that, as the best means of enlarging its business and meeting competition, the management of the Company is steadily pursuing the policy of reducing the cost to customers while improving the standard of its products. In this endeavor the management is constantly seconded by the unceasing activity of Mr. EDISON, and by the intelligence, skill and experience of a number of its officers and employes. The difference between the present manufacturing methods at our Works and those of a few years ago, shows how great is the progress that has been made. A striking illustration is the reduction in the cost of our incandescent lamp.

In view of the value of Mr. EDISON'S services, the Board of Trustees take particular satisfaction in stating that the Company has entered into a new contract with him, under which he devotes the greater portion of his time to experiments and inventions for it; and the facilities of his Laboratory at Orange, N. J., are placed at the disposal of this Company.

THE MANUFACTURING ESTABLISHMENTS.

There was expended during the year a total of $949,274.70 for new buildings, new machinery and other additions to the permanent plants. Of this amount $777,752.64 was invested in the Works at Schenectady, and includes the cost of buildings and a portion of machinery for an entirely new branch of business, the manufacture of underground cables, under the patents of the well-known firm of Messrs. SIEMENS & HALSKE, of Berlin, Germany, from which large profits are expected. The new investments have more than doubled the capacity of the Schenectady Works, and the number of employes was increased from 1,700 to 2,900, while the total product manufactured and sold shows an increase of 117 per cent. over the preceding year.

The enlargement of the Lamp Works, at Harrison, N. J., called for an outlay of $100,000 (of which $47,554.27 has already been spent), which will increase their capacity from a daily output of 11,000 lamps to 25,000 lamps. The reduction in the price of its lamps, which this Company was able to make two months ago in consequence of economies in their manufacture, for which it is indebted to the ingenuity of Mr. EDISON, has already more than doubled its orders. The sales of lamps increased 64 per cent. over the previous year. The number of employes rose from 379 to 605.

The business of the New York Works, formerly known as BERGMANN & Co., increased 31 per cent., and the employes from 704 to 895.

The growth of the Canadian business will make it necessary to abandon the present small shop at Sherbrook, in the Province of Quebec, as soon as the new and larger Works now being erected at Peterborough, in the Province of Ontario, are finished. The present force of 204 men will then be transferred from Sherbrook and largely increased.

EARNINGS.—THE GENERAL BALANCE SHEET AND PROFIT AND LOSS ACCOUNT.

According to the balance sheet and profit and loss account printed herewith, the gross profits of the business during the year, after deducting $266,071.27 set aside for depreciation of the plants of the several Works, and $206,679.15 for General Expenses, without including the royalties received by the Edison Electric Light Company, amounted to $1,896,177.06. From this sum various other amounts have been written off, as set forth below. The 6½% deduction for depreciation was made on the entire plant, notwithstanding additions of $949,274.70, (or about 23¼%, to the property accounts of the manufacturing plants) during the year, on which no appreciable depreciation could have taken place.

The General Company owns practically all of the capital stock of the Edison Electric Light Company, and therefore its profits may be considered as part of the General Company's resources. From the statement of the Light Company, also printed herewith, it appears that its net receipts during the fiscal year were $1,023,011.29 in cash and stocks and bonds of licensed local companies. In accordance with the policy which the Light Company has always pursued, this sum, together with stocks and bonds formerly acquired, is held in its treasury undistributed.

At the close of the previous fiscal year, there remained a balance of $679,401.48 to the credit of Profit and Loss on the General Company's books. The gross profits of the General Company during the year under review bring the total up to $2,782,257.69. From this there have been deducted $206,679.15 for general expenses; $100,000 charged off against patents; $614,711.41 charged off against cost of acquisition of stocks of sub-companies whose business has been consolidated into this Company; and $665,314. for dividends distributed; after which there remains $1,195,553.13 carried into the new year at the credit of Profit and Loss. This sum does not include the business of the Light Company as above set forth.

The balance sheet of the General Company shows that the quick assets, consisting of cash, bills receivable and accounts receivable, amount to $3,619,063.59, while the entire liabilities of the corporation, other than those to its stockholders, amount to only $2,647,828.41. Adding to the quick assets above stated the sum of $4,272,903.63, which represents amounts expended on contracts in course of completion, and materials on hand and in process of manufacture, the active working capital of the Company over and above its liabilities, appears to be about five and one-quarter millions of dollars.

All materials in stock and in process of manufacture are carried at net invoiced prices. The materials and expenditures on uncompleted work in progress are carried on the books at cost, and without any allowance for profits. This should be kept in mind in considering the value of the total of $4,272,903 63 above referred to.

The Board of Trustees express the thanks of the corporation to all officers and employes for their faithful and efficient service.

BY ORDER OF THE BOARD OF TRUSTEES.

HENRY VILLARD,
President.

Edison General Electric Company.

General Balance Sheet, October 31st, 1890.*

ASSETS.

MANUFACTURING PLANTS		$4,085,160.70
PATENTS (on manufacturing processes and articles manufactured)		296,243.98
REAL ESTATE (on Broad St., N. Y. City)		264,352.28
CAPITAL STOCK OF EDISON ELECTRIC LIGHT CO.		4,343,050.13
ENTIRE CAPITAL STOCK OF SPRAGUE ELECTRIC RAILWAY AND MOTOR CO. (representing Sprague Patents)		680,000.00
SUNDRY STOCKS AND BONDS (of various local Electric Illuminating and Electric Street Railway Companies received in part payment for work done)		398,078.50
C [illegible]	$434,582.75	
BILLS RECEIVABLE	983,805.69	
ACCOUNTS RECEIVABLE	2,200,675.15	3,619,063.59
WORK IN PROGRESS (cost to date of all labor, material, etc., on uncompleted Installations)	$1,266,173.85	
MATERIALS AND SUPPLIES (on hand and in process of manufacture)	$3,006,729.78	4,272,903.63
		$17,958,852.81

LIABILITIES.

ALLOWANCE FOR DEPRECIATION (for the Fiscal Year ending Oct. 31, 1890: (6½% on all Manufacturing Plants,)		$266,071.27
MORTGAGES ON REAL ESTATE		200,000.00
CAPITAL STOCK	$9,370.700.00	
CAPITAL STOCK HELD IN TRUST BY THE FARMERS LOAN AND TRUST CO.	2,478,700.00	
OUTSTANDING NOTES PAYABLE IN STOCK AT PAR	2,000,000.00	13,849,400.00
BILLS PAYABLE	1,776,752.48	
ACCOUNTS PAYABLE	671,075.93	2,447,828.41
PROFIT AND LOSS, Surplus carried forward Oct. 31, 1890,-		1,195,553.13
		$17,958,852.81

* This Balance Sheet includes all assets and shows every liability of the Corporation's entire business, viz: of the General Office, of all Works, and of all District Offices.

E. & O. E.—New York, January 19th, 1891.

J. P. ORD, *Comptroller.*

Edison General Electric Company.

Statement of Profit and Loss Account, October 31st, 1890.

EXPENSES.

EXPENSES OF GENERAL OFFICE,	$168,926.00	
MISCELLANEOUS EXPENSES,	37,753.15	$206,679.15
ITEMS NOW WRITTEN OFF:		
Patents	$100,000.00	
Net amount charged off during the current fiscal year against cost of acquisition of Capital Stocks of various Sub-Companies, whose business has been consolidated into this Company	614,711.41	714,711,41
DIVIDENDS PAID.		665,314.00
BALANCE.—Surplus carried forward		1,195,553.13
		$2,782,257,69

EARNINGS.

PROFIT AND LOSS, Surplus brought over, Oct. 31st, 1889,	$679,401.48
INTEREST ACCOUNTS, Balance for the year, including dividends received	4,740.18
PROFITS from Nov. 1st, 1889, to Oct. 31st, 1890, not including those of the Edison Electric Light Company,	2,098,116.03
	$2,782,257.69

E. & O. E.—New York, January 19th, 1891.

J. P. ORD, *Comptroller.*

Edison Electric Light Company.

Balance Sheet, October 31st, 1890.*

ASSETS.

PROPERTY ACCOUNTS.		
Permanent Plant	$9,665.59	
Rental Plants	21,307.77	$30,973.36
TRUST FUND		51,612.39
CASH ACCOUNTS	$7,628.90	
BILLS RECEIVABLE	10,725.36	
OPEN ACCOUNTS	162,400.92	
DOUBTFUL AND EXTENDED ACCOUNTS	4,274.07	185,029.25
STOCKS AND BONDS		2,888,841.00
PATENTS		1,242,316.52
		$4,398,772.52

LIABILITIES.

CAPITAL STOCK		$1,500,000.00
BILLS PAYABLE	$110.000.00	
ACCOUNTS PAYABLE	541.26	110,541.26
SINKING FUND (against Cost of Patents)		1,239,064.49
GENERAL LIQUIDATION ACCOUNT		40,806.28
PROFIT AND LOSS ACCOUNTS.		
Profit and Loss, Sept. 30th, 1889	$466,114.34	
Profit fiscal year ending Sept. 30th, 1890.	1,023,011.29	
	1,489,125.63	
Profit current year to date (1 month)	29,660.03	
	1,518,785.66	
Less Expenses current year to date (1 month)	10,425.17	1,508,360.49
		$4,398,772.52

E. & O. E.—New York, January 19th, 1891.

J. P. ORD, *Comptroller.*

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* The fiscal year ends September 30th.

The Edison Incandescent Lamp Case.

Full Text of Judge Wallace's Opinion in the Case of The
Edison Electric Light Company against the
United States Electric Lighting Company,
filed in the U. S. Circuit Court,
New York City, July 14, 1891.

Mr. Edison Declared to be the Inventor of the
Incandescent Electric Lamp. An Injunction
and Accounting Ordered.

Published by the Edison General Electric Company,
(Edison Building,) 44 Broad Street, New York.

PUBLIC LEDGER
AND DAILY TRANSCRIPT.

Philadelphia, Tuesday, Oct. 8, 1889.

1892 should be a national ... private speculation.

THERE IS SUBSTANTIAL JUSTICE in the defeat of the Westinghouse Company in its attempt to set up the Sawyer-Mann patent for a fibrous carbon, in order to get control of incandescent electric lighting as against the Edison Company. Whatever the facts may be as to the dates of patents, it is certain that Sawyer and Mann had abandoned the use of the fibrous carbons until Edison showed them how to make and use the filaments. Months after Edison had lighted Menlo Park, Sawyer, in a public speech in this city, denied the possibility of making the carbon so as to last 15 minutes. He was then engaged in exhibiting a pencil carbon lamp that was a cross between arc and incandescent. It would be ridiculous to say now that he invented a lamp which he pronounced impracticable at the very time that Edison was exhibiting it in actual use for the first time.

EXTRACT.

"He" (Edison) "was the first to make a carbon of materials and by a process which was especially designed to impart high specific resistance to it; the first to make a carbon in the special form for the special purpose of imparting to it high total resistance; and the first to combine such a burner with the necessary adjuncts of lamp construction to prevent its disintegration and give it sufficiently long life. By doing these things he made a lamp which was practically operative and successful, the embryo of the best lamps now in commercial use, and but for which the subdivision of the electric light by incandescence would still be nothing but the *ignis fatuus*, which it was proclaimed to be in 1879 by some of the learned experts who are now witnesses to belittle his achievement and show that it did not rise to the dignity of an invention."

CIRCUIT COURT OF THE UNITED STATES

FOR THE SOUTHERN DISTRICT OF NEW YORK.

THE EDISON ELECTRIC LIGHT COMPANY

vs.

THE UNITED STATES ELECTRIC LIGHTING COMPANY.

WALLACE, Circuit Judge:

Two claims of Letters Patent No. 223,898, granted Thos. A. Edison, January 27th, 1880, for an improvement in electric lamp, are in controversy in this suit. These are claims 1 and 2. It is not asserted for plaintiff that the defendant infringes the other claims of the patent, consequently they will require no attention further than to see whether their terms may assist in defining the meaning of the claims in litigation.

The plaintiff contends that these claims are for fundamental inventions of great merit, and are entitled to a construction by which every incandescent lamp for electric lighting, consisting essentially of a filamentary carbon burner, hermetically sealed in a glass vacuum chamber, is within their terms. The defendant contends that unless the claims are limited to narrow inventions, not employed by the defendant, they are invalid for want of patentable novelty. The questions of the validity and scope of the patent have been adjudicated in the Courts of England and Germany with a diversity of opinion by the Judges who have considered them. The specification is a perplexing one. The difficulty lies in its shadowy demarkation of the line between the essential and non-essential features of the invention described. It catalogues a number of discoveries which Mr. Edison has made; it sets forth some of the essential features of the lamp, and then it leaves to be found by inference from generalities what the elements are of the combinations included in the extremely elastic terms of the two important claims. Nevertheless, when a sufficient knowledge of the prior state of the art to which it relates has been acquired, the new departures from old devices which it describes, and which, presumably, the inventor proposed to incorporate into the claims of his patent, are reasonably apparent. The specification states that the object of the invention is "to produce electric lamps giving light by incandescence, which lamps shall have high resistance so as to allow of the practical subdivision of the electric light." The subdivision of the electric light is the concrete term for the division of the electric current into numerous small units and their conversion into luminous centres. By practical subdivision is meant a distribution and division of the current and its conversion into lights comparable with those of ordinary gas jets, on a scale and under conditions of convenience and economy adequate to a system of illumination for domestic purposes, in villages and cities, analogous to that of gas. Prior to 1879 there was no method known by which this could be done practically. The problem involved the perfection of devices for the proper distribution and regulation of the current as well as those for translating it into light. No reference to the pre-existing devices for generating electricity, conducting it to the translating devices, or regulating its pressure and quantity, is necessary except to state that the principles governing the relation of the resistance of translating devices to the character of the circuit in which they are arranged, whether in series or in multiple arc, were well known to electricians and had been applied in various forms of electrical apparatus. There were two well-known devices for converting the current into light—the arc lamp and the incandescent lamp. In the former the current is forced to leap an air gap separating two conductors, usually of carbon, and in overcoming the resistance of the air space heats the adjacent surfaces of the conductors and produces a light of great intensity. In the latter light is produced by the incandescence of an electrical conductor, a conducting strip or burner, placed in a continuous circuit through which the current passes and which develops heat by its resistance to the flow. The arc lamp was suitable for use in streets, open spaces and large halls, but its light was too concentrated and powerful for the illumination of dwellings or rooms of small dimensions. It was the generally accepted opinion of electricians that the hope of progress in the subdivision of the electric light was to be found in modifying the features of the arc lamp. The reasons for this conclusion need not be mentioned; it suffices to say that Mr. Lane-Fox in England, and Mr. Edison in this country, seem to have been the only notable dissidents, and each of them had expressed the conclusion that subdivision might be accomplished by the incandescent lamp when provided with a conductor of high resistance and small radiating surface arranged in a system of multiple arc. Lane-Fox had set forth the advantages of such a lamp in three patents granted to him in England, two in October, 1878, and one in March, 1879, and in a letter to the "London Times" published in December, 1878; and Mr. Edison had done so in a patent granted to him in France, May 28th, 1879, for improvements in electric lighting.

By arrangement in multiple arc no greater electromotive force is required for a large number of translating devices than for a single one, and the amount of current can be graduated to the number employed;

consequently, a lamp with a conductor of high resistance can be utilized as efficiently as one with a conductor of low resistance. Higher resistance in the conductor permits the use of a weaker current, and consequently, of smaller and less expensive main conductors. With a small surface of conductor less energy is required to produce a candle-power, and the small incandescent mass will radiate a moderate light, like the domestic lamp. Electricians knew how to make conductors of high resistance, and how to make them with a small radiating surface. They knew that with material of the same specific resistance the total resistance of the conductor could be varied by varying its length or cross-section, high resistance being imparted by length and small section. They knew what materials were preferable, and what processes of treatment, to make conductors of high or low resistance. If they had only known how to construct a lamp in which the conductor would have adequate mechanical strength and durability for practical commercial use, while having the small radiating surface and high resistance desirable, there would have been nothing wanting, and electric lighting by incandescence would soon have been an accomplished fact. Although Lane-Fox and Edison had contributed to the state of the art the recognition of the principle that the conductor must have high resistance and small radiating surface, and each of them had embodied the principle in lamps for which they had severally obtained patents, neither of them had invented a lamp which satisfactorily met all the conditions of success, because a burner of the necessary materials, form and complementary adjuncts was yet to be devised. As to materials, experiments had been tried with platinum, iridium and alloys of these metals, and with carbon of various kinds. It was known that platinum, being a poor conductor, could be readily brought to incandescence by the electric current, but to do so it was necessary to raise it to a temperature very near the fusing point, and a minute increase would melt it. On the other hand, carbon was known to possess at an equal temperature much greater power of radiation than platinum, but the difficulty was that it would combine with oxygen at high temperature and rapidly disintegrate. It could only be used, therefore, in a vacuum from which the oxygen had been excluded, and a perfect vacuum was practically unattainable. From the earliest lamp (disregarding the Geissler tube, because it has no burner in the true sense), patented in England by King in 1845, to the latest examples, like those of Lane-Fox or Edison's platinum lamp, patented in 1878–9, the history of the art shows a variety of experiments to perfect a lamp in which a carbon burner, or a platinum burner, would have sufficiently long life for practical requirements. The result of these experiments may be succinctly shown by quoting two well-known electricians. Mr. Schwendler, in an article published in 1879, in the "Telegraphic Journal," said: "Unless we shall be fortunate enough to discover a conductor of electricity with a much higher melting point than platinum, and the specific weight and the specific heat of which conductor is also much lower than for platinum, and which at the same time does not combine at high temperatures with oxygen, we can scarcely expect that the principle of incandescence will be made use of for practical illumination." Mr. Sawyer, in a patent to Sawyer and Man, granted in June, 1878, said: "At the present day it is not new to produce a light by causing the electric current to heat a carbon conductor to incandescence in a vacuum, or in nitrogen, or in other gas; but no lamp has yet been devised which would be practically operative, and for these reasons: First, the methods which have been adopted for charging the lamp with the artificial atmosphere, such as a displacement of mercury, water or air by the gas, or the combustion of phosphorus in the lamp, are imperfect. A perfect vacuum is unattainable. Some oxygen, or other element or compound, remains in the lamp, and slow consumption or disintegration takes place, for the remaining gas or vapor other than hydroden or nitrogen attacks the carbon, which in turn is decomposed, with a result of depositing the carbon upon the globe and setting free the oxygen to attack fresh carbon. Second, it has been found practically impossible under the varying degrees of heat and pressure to maintain perfect joints, and the result is that expansion of the artificial atmosphere by the heat from the luminous conductor expels a portion of the same, and the contraction of the atmosphere upon cooling causes a portion of the external air to penetrate the globe, thus supplying oxygen, which at the next lighting feeds upon the carbon. Third, the unequal expansion of the carbon and its holders has resulted in fractures of the former, so that, however perfect the atmosphere in the globe, the lamp has never been permanent."

The most advanced type of carbon burner lamps in 1875 were the lamps of Lodyguine or of Konn, and until the spring of 1879, lamps like those of the Sawyer & Man patent or the patent of Mr. Farmer. It was thought to be the merit of Lodyguine's lamp that it obviated the difficulty of the short life of the burner by using two burners, rods of diminished section at the luminous focus, in a glass receiver, hermetically sealed and filled with nitrogen, electrically arranged so that the current could be passed to the second carbon when the first had been consumed. Mr. Konn provided his lamp with five carbon burners in the form of rods or pencils and devices for bringing them successively into circuit. In the lamp of Sawyer & Man the carbon burner was a rod or pencil maintained in a globe charged with nitrogen gas, and the globe and its stopper (both of glass) were held together by a clamping device. In the lamp of the patent granted to Mr. Farmer in March, 1879, the burner was a carbon rod or pencil enclosed in a globe filled with nitrogen or other analogous gas, and the globe was closed by a rubber stopper. In none of the lamps, except the one described in Mr. Edison's prior French and English Patents of 1879, had any attempt been made to make the vacuum chamber wholly of glass with the parts sealed together by fusion, or to seal the conducting wires leading to the burner through the glass by fusion of the glass. The impracticability of maintaining a carbon burner under such conditions that it would be sufficiently durable had apparently so impressed those who were studying lighting by incandescence, that we find that as late as in the early part of 1879 both Lane-Fox and Edison were trying to perfect a burner of other material. Edison's burner, in his French Patent of May 28th, 1879, and his English Patent of June 17th, 1879, was of platinum wire coiled upon a bobbin composed of an infusible oxide; and Lane-Fox's burner, in his patent of May 14th, 1879, was of platinum-iridium alloy, or of spiral strips of metal surrounding a tube of glass, fire clay, steatite or lime, with the surface of the metal strips covered with asbestos or some vitreous material.

This cursory view of the prior state of the art is sufficient for an intelligent reading of the specification. The specification describes the general nature of the invention as follows:

"The invention consists in a light-giving body of carbon wire or sheets coiled or arranged in such a manner as to offer great resistance to the passage of the electric current, and at the same time present but a slight surface from which radiation can take place."

"The invention further consists in placing such burner of great resistance in a nearly perfect vacuum to prevent oxidation and injury to the conductor by the atmosphere. The current is conducted into the vacuum bulb through platina wires sealed into the glass."

"The invention further consists in the method of manufacturing carbon conductors of high resistance, so as to be suitable for giving light by incandescence, and in the manner of securing perfect contact between the metallic conductors or leading wires and the carbon conductor."

The specification then recites that previously light by incandescence had been obtained from rods of carbon of one to four ohms of resistance, placed in closed vessels in which the atmospheric air had been replaced by gases that did not combine chemically with the carbon; that the vessels holding the burner had been composed of glass cemented to a metal base; that the connections between the leading wires and the carbon has been obtained by clamping the carbon with the metal; that the leading wires had always been large, so that their resistance should be many times less than the burner, and generally the attempts of previous persons had been to reduce the resistance of a carbon rod. It then points out the disadvantages of such a lamp, stating that it could not be worked in great numbers in multiple arc without the employment of main conductors of enormous dimension; that, owing to the low resistance the leading wires have to be of large dimensions and good conductors, and a glass globe cannot be kept tight at the place where the wires pass in and are cemented, and consequently the carbon is consumed because there must be almost a perfect vacuum to render it stable, especially when it is small in mass and high in electrical resistance; and that the use of gas in the receiver at the atmospheric pressure serves to destroy the carbon by attrition.

The specification then states in substance that the patentee proposes a new departure; and that he has discovered that even a cotton thread properly carbonized and placed in a sealed glass bulb exhausted to one-millionth of an atmosphere offers from one hundred to five hundred ohms resistance to the passage of the current, and that it is absolutety stable at very high temperature; that if the thread be coiled as a spiral and carbonized, or if any fibrous vegetable substance which will leave a carbon residue after heating in a closed chamber be so coiled, as much as two. thousand ohms resistance may be obtained without presenting a radiating surface greater than three-sixteenths of an inch; that if such fibrous material be rubbed with a plastic composed of lamp-black and tar its resistance may be made high or low, according to the amount of lamp-black placed upon it; that carbon filaments may be made by a combination of tar and lamp-black, the latter being previously ignited in a closed crucible for several hours, and afterwards moistened and kneaded until it assumes the consistency of thick putty; that small pieces of this material may be rolled out in the form of wire as small as seven one-thousandths of an inch in diameter and over a foot in length, and the same may be coated with a non-conducting, non-carbonizing substance and wound on a bobbin, or as a spiral, and the tar carbonized in a closed chamber by subjecting it to high heat, the spiral after carbonization retaining its form; that he has carbonized and used cotton and linen thread, wood splints, papers, coiled in various ways, also lamp-black, plumbago, and carbon in various forms, mixed with tar and kneaded so that the same may be rolled out into wires of various lengths and diameter; that each wire should be uniform in size throughout; that all these forms are fragile and cannot be clamped to the leading wires with sufficient force to insure good contact and prevent heating; that if platinum wires are used and the plastic lamp-black and tar material be molded around it in the act of carbonization, there is an intimate union by combination and by pressure between the carbon and platinum and nearly perfect contact is obtained without the necessity of clamps; that the burner and the leading wires should be connected to the carbon ready to be placed in the vacuum bulb, and when fibrous material is used the plastic lamp-black and tar should be used to secure it to the platina before carbonizing.

The specification proceeds as follows:

"By using the carbon wire of such high resistance I am enabled to use fine platinum wires for leading wires, as they will have a small resistance compared to the burner, and hence will not heat and crack the sealed vacuum bulb. Platina can only be used as its expansion is nearly the same as that of glass."

"By using a considerable length of carbon wire and coiling it the exterior, which is only a small portion of its entire surface, will form the principal radiating surface; hence I am able to raise the specific heat of the whole of the carbon and thus prevent the rapid reception and disappearance of the light, which on a plain wire is prejudicial, as it shows the least unsteadiness of the current by the flickering of the light, but if the current is steady the defect does not show."

The specification then gives directions for carbonizing the carbon thread in a manner to prevent its distortion, for blowing a glass bulb over it after it is formed, for exhausting the glass bulb, and for hermetically sealing the bulb when a high vacuum has been reached.

The claims are as follows:

"1. An electric lamp for giving light by incandescence, consisting of a filament of carbon of high resistance, made as described, and secured to metallic wires, as set forth."

"2. The combination of carbon filaments with a receiver made entirely of glass and conductors passing through the glass, and from which receiver the air is exhausted, for the purposes set forth."

"3. A carbon filament or strip coiled and connected to electric conductors so that only a portion of the surface of such carbon conductors shall be exposed for radiating light, as set forth."

"4. The method herein described of securing the platina contact wires to the carbon filament, and carbonizing of the whole in a closed chamber, substantially as set forth."

The specification is addressed to those who were skilled in the art to which it relates; who appreciated the advantages of arranging incandescent lamps in a system of multiple arc, and of providing the lamp with a burner of high resistance and small radiating surface; who knew how high resistance, both specific and total, is imparted to a conductor; who knew that the rods, pencils, or other forms of carbon burners previously used, had not been designed to embody the principle of high resistance; who knew how desirable it was to maintain the burner in a perfect vacuum, or in gases that would exclude the oxygen; who knew what had been attempted and had proved impracticable in that behalf; who knew that such materials as are mentioned in the specification (even the tar-putty compound seems to have been used in Gauduin's process) would compose a carbon of high resistance when subjected to a proper process of carbonization; and who knew how to practice proper processes for the carbonization of such materials.

Read by those having this knowledge the radically new discovery disclosed by the specification is that a carbon filament as attenuated before carbonization as a linen or cotton thread, or a wire seven one-thousandths of an inch in diameter, and still more attenuated after carbonization, can be made which will have extremely high resistance and be absolutely stable when maintained in a practically perfect vacuum. It informs them of everything necessary to utilize this discovery and incorporate it into a practical lamp. It describes, with the assistance of the recital in the second claim, as the vacuum in which the burner is to be maintained, a bulb made wholly of glass, exhausted of air, sealed at all points by the fusion of the glass, and in which platinum leading wires are sealed by the fusion of the glass. It describes the materials of which the burner is to be made and instructs them that the materials are to be shaped into their ultimate form before carbonization. It describes the use of platinum for the leading wires, and a method of securing the leading wires and filaments, intended to dispense with clamping, which consists in molding tar putty about the joints, and carbonizing the whole in a closed chamber. Besides stating that the resistance of the burner will be greatly increased and the radiating surface still be kept within moderate limits by coiling it in the form of a spiral, the specification states that by increasing the length of the filament coiled, the exterior only will be the principal radiating surface, and greater steadiness of illumination will be promoted.

The first claim must be read with several limitations. The filament is to be made of carbon of high resistance; that is, as the experts agree, of high specific resistance. The filament is to be made as described; that is, the materials are to be of some of the kinds described, and are to be shaped in filamentary form and then carbonized. The filament is to be secured to metallic wires according to the method of the patent; because the claim implies the elements of a globe and metallic conductor arranged in circuit with the burner, otherwise the combination would not be operative, and it would have been needless to specify the securing of the metallic wires to the filament unless it was intended to import into the claim the specific method of doing so emphasized in the specification.

The defendant does not infringe this claim, if for no other reason, because the leading wires in its lamps are not secured to the filament according to the method of the patent; that is, by cement carbonized *in situ*, but by clamps such as the specification condemns.

The second claim is broad enough in its phraseology to secure the real invention described in the specification, and can be read consistently with its language so as to import into it every essential limitation.

It was a remarkable discovery that an attenuated thread of carbon would possess all the long-sought qualities of a practical burner when maintained in a perfect vacuum. The extreme fragility of such a structure was calculated to discourage experimentation with it, and it does not detract in the least from the originality of the conception that previous patents had suggested that thin plates, or pencils, or small bridges could be used. The futility of hoping to maintain a burner in vacuo with any permanency had discouraged prior inventors, and Mr. Edison is entitled to the credit of obviating the mechanical difficulties which disheartened them, but what he did in this respect was a matter of only secondary merit and was no longer new in the art, because he had already disclosed it in his French and English Patents. What he actually accomplished was to unite the characteristics of high resistance, small radiating surface, and durability in a carbon conductor by making it in a form of extreme tenuity, out of any such materials as are mentioned in the specification, carbonizing it, and arranging it as he had previously arranged his platinum burner in an exhausted bulb made wholly of glass and sealed at all points, including those where the leading wires entered, by the fusion of the glass. He was the first to make a carbon of materials and by a process which was especially designed to impart high specific resistance to it; the first to make a carbon in the special form for the special purpose of imparting to it high total resistance; and the first to combine such a burner with the necessary adjuncts of lamp construction to prevent its disintegration and give it sufficiently long life. By doing these things he made a lamp which was practically operative and successful, the embryo of the best lamps now in commercial use, and but for which the subdivision of the electric light by incandescence would still be nothing but the *ignis fatuus*, which it was proclaimed to be in 1879 by some of the learned experts who are now witnesses to belittle his achievement and show that it did not rise to the dignity of an invention.

The coiled form of the burner is only an alternative feature, and is not a constituent of the second claim. It is the subject of the third claim. Nor is the bent form or any form other than the filamentary. It may be that in the haste which has always seemed to characterize Mr. Edison's efforts to patent every improvement, real or imaginary, which he has made or hoped to make, he had not stopped to reflect when he framed his application for the patent that the filamentary burner would do its work just as well uncoiled as coiled provided the same length and cross-section were used. It is true that it is said in the general statement of the nature of the invention that the burner is so "coiled or arranged" as to offer high resistance and present a small radiating surface; but this description is satisfied by any arrangement, whether by coiling a considerable length in a small globe or using the same length uncoiled in a larger globe, by which sufficient total resistance is obtained from a filament of small diameter. It certainly would not involve invention to omit the coiling and elongate the globe; hence, it is manifest that the invention described is the same thing essentially whether the coiled form is used or not. The language is satisfied, if the burner is filamentary and so arranged as to offer great resistance and slight radiation, without importing into it anything which is not of the essence of the invention. No precise limitation upon the maximum diameter of the filament can be defined from the specification or is required as an element of the claim. The specification mentions by way of illustration the threads of linen or cotton which become more attenuated after carbonization, and the carbon wire which after carbonization would be from four to five one-thousandths of an inch in diameter; while the smallest rods of carbon previously known were about a millimeter in diameter, thus having a cross-section fifty times as great as the carbon wire. It is to be implied from the suggestions in the specification that it is to have sufficiently high total resistance for efficient use when the lamps are arranged in multiple arc, and to be used with leading wires of fine platinum. The claim is not limited to a carbon filament made of non-fibrous material. The conductors of the claim are the platinum wires mentioned in the specification. The receiver is the vacuum described in the specification. The peculiar method of securing the conductors to the filament, made a constituent of the first claim, is not imported into the second claim. A more exact interpretation of the meaning of the claim than has thus been indicated is not necessary in the present case, because each of the three lamps representing the kinds used by the defendant embodies the invention of the claim as thus interpreted.

It is of little import what Mr. Edison, or his patent solicitor, may have thought about the meaning of the claim during the pendency of the application for a subsequent patent, or that Mr. Edison may have supposed a resistance as high as one hundred ohms in the burner would be required for use with the means of distribution which he expected to employ with his system of

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lighting. There are many adjudicated cases in which it appears that the inventor builded better than he knew; where a patent has been sustained for an invention the full significance of which was not appreciated by the inventor when it was made. In the case of the Bell Telephone patent there was great room for doubt whether the speaking telephone had been thought of by Mr. Bell when he filed his application for a patent, but the Court said: "It describes apparatus which was an articulating telephone, whether Bell knew it or not" 22 Blatch., 532.

The nearest approach in the prior art to the invention of the second claim is undoubtedly the lamp of Edison's French and English Patents with a platinum burner. It seems almost preposterous to argue that the substitution of the carbon filament for the platinum burner of that lamp was an obvious thing to electricians. It would have been probably if there had been such a thing as a filamentary carbon in the prior art. But the nearest approximations to it were the ribbon shaped carbon burner of low resistance of Mr. Farmer (which was not a part of the prior art but an isolated example known only to a select few) and the low resistance carbon rod burners of the patent of Sawyer & Man.

Undoubtedly the improvements that have been made in the art, such for instance as the method of electrical carbonization of the filament, since Mr. Edison's invention, have been of great value, and the perfected commercial lamp of to-day is far superior to the one which could be made by applying to the description of the patent all the knowledge and skill then possessed by those to whom it was more particularly addressed. But as was said by BOWEN, L. J., in the Court of Appeal in England, "the evidence shows that lamps made solely on the patent will and do succeed, although subsequent improvements have been engrafted on the original design." It is impossible to resist the conclusion that the invention of the slender thread of carbon as a substitute for the burners previously employed opened the path to the practical subdivision of the electric light.

The questions which have seemed the most meritorious of those argued at the bar have now been considered. Others, to which no reference has been made, have not been overlooked, and may be dismissed without discussion and with the single remark that nothing which has been presented by the voluminous proofs and the exceedingly able and elaborate arguments of counsel seems to supply any valid reason for refusing to decree for the plaintiff.

The usual decree for an injunction and accounting is accordingly ordered.

EDISON UNITED MANUFACTURING CO.

65 FIFTH AVENUE, NEW YORK,

SOLE LICENSEE

OF THE

EDISON ELECTRIC LIGHT CO.

FOR SALE OF

ELECTRIC LIGHT PLANTS

UPON THE CASH BASIS;

INCLUDING

ALL ISOLATED PLANT INSTALLATIONS

—AND—

ALL CENTRAL STATIONS

IN TOWNS WHICH IN 1880 HAD A POPULATION NOT
EXCEEDING 10,000 INHABITANTS.

THE EDISON SYSTEM OF CENTRAL STATION LIGHTING.

BEFORE investing his money, a prudent man will inquire as to the character and scope of the enterprise in which he contemplates embarking.

In this connection, attention is called to the fact that the term "Electric Lighting" is so wholly inadequate as a description of the ***industry of manufacturing, distributing*** and ***selling*** electrical energy, as to be misleading in the extreme.

Any "system" which is available only for the single purpose of lighting is necessarily so heavily handicapped, as against a system which is capable of universal adaptation, as to be practically out of the race.

It is imperative, therefore, that the intending investor shall inquire as to the adaptability of the system presented to his notice to all the requirements of the community which he desires to serve, as, for instance: Light, Power, Heat, Ventilation, and the manifold industrial and other uses to which electricity is now being applied with phenomenal rapidity.

To the end of directing the inquirer intelligently, we will endeavor to indicate of what and how such a universal system is constituted.

A universal system must possess the following elementary components:

1st. A continuous current in one direction.
2d. Uniform pressure.
3d. Maximum of safety.
4th. Absolute reliability.
5th. A practically unlimited supply.
6th. Minimum cost.
7th. Means of measuring.
8th. Complete control by the user of the energy supplied to him.

It is owing to the fact that these components are all em-

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bodied in the Edison system that we are enabled to point to the work done by the Edison Companies and show over one million lamps in active successful operation in the United States.

THE TWO KINDS OF ELECTRIC LIGHTS.

THE term "electric light" conveys to the majority of people but one impression, that of a very bright light which flickers and hurts the eyes of those who use it, and which employs an electric current of such strength as to cause the instant death of those who receive its full force. These lights are known as "arc lights," and are familiar to every one from the fact of their being used to light the streets of cities and towns. These lights have their uses and advantages, but where one arc lamp is used by the public there is a demand for a thousand of those small, soft, perfectly steady lights of the brightness of a good gas jet, or as much brighter as is wished, known as incandescent electric lights, with which the name of Edison is linked throughout the entire civilized world. These incandescent lamps are not intended to produce as large an amount of light at one point as an arc lamp, but the power used in an arc light can be used to produce from 10 to 20 incandescent lights, which may be so placed, that in a great majority of cases, much more satisfactory results are produced than can be obtained from an arc light; in fact it was to accomplish this subdivision that Mr. Edison invented the incandescent lamp.

THE SUPERIOR ADVANTAGES OF THE EDISON LIGHT.

THE general adoption of the incandescent electric light by the public is no longer a matter of uncertainty. Wherever an Edison central station has been established, the light has become popular and has been generally adopted, ***no matter what other light contested the field.*** The greater value of this statement will be more apparent when we add that there are upwards of ***one hundred and twenty-five Edison central stations*** at present in operation in the United States.

The fact has been fully demonstrated that *the general public appreciate the advantages of the incandescent light.* Not only do they appreciate these advantages, but they *are willing to pay for them.*

EDISON 16-CANDLE POWER LAMP.

The advantages claimed for the incandescent electric light are not imaginary, but are real and substantial; argument is not needed to show them; they are now seen and appreciated by the general public almost universally.

The sanitary advantages of the light are conceded, but the qualities above all others which recommend it, are its ***safety*** and ***easy adaptability*** to all conditions.

The light can be applied more directly and efficiently than any other light, the lamps being inverted; their supports cast no downward shadows, and the whole of the light is thrown on the work to be lighted. As the lamps give very little heat and no flame, they can be used in positions in which no other light could be placed.

For desk lights they have no equal; they can be used near the head without discomfort from heat, and the light can be shielded from the eyes and thrown upon the desk as no other light can be. The fact that the lamps produce no gases, and can be used in a current of air, render them invaluable in many cases.

The special applications of the light to conditions which no other light can fill are innumerable, and very many users of the light have obtained results which they never could produce with other lights.

CONVENIENCE.

THE ability to light or extinguish a lamp at any time from a point at a distance from the lamp, leads to many useful and popular applications. For instance: a cellar, garret, passageway, or room may be lighted before entering, and the light extinguished after leaving. As, usually, the object of turning down the gas on leaving the room is to save the trouble of relighting it in the dark, this fully meets the objection that the incandescent light cannot be turned down.

If it is desired to have a dim light burning in a room at night this may be done, or a switch may be placed at a bedside, by which the room may be lighted in a moment at any time. Many places, such as stables, refrigerating rooms, or places where fire risk is great, can be well lighted by this light, where artificial lights would be dangerous if not impracticable.

LAMPS OF VARIOUS CANDLE POWER.

THE Edison system supplies lamps of 4, 6, 8, 10, 13, 16, 20, 24, 32, 50, 100, 150 and 250 candle power per lamp, which can be used interchangeably at any point throughout the circuits. To the producer who sells the light, and to the consumer who buys it, these are some of the elements of commercial success.

LIGHTING FROM CENTRAL STATIONS AND BY PRIVATE OR ISOLATED PLANTS.

WE have two distinct methods of supplying the Edison light to the public: the first, embodying the principles which Mr. Edison has from the beginning proposed, namely, the establishment of central stations and the supplying of light to a large number of customers from this source, in the same manner as gas is supplied by gas companies. The second method is the sale outright of all the necessary apparatus for the production of the light in private establishments.

Many factories, steamboats, stores, hotels, etc., use so much light that it pays them to make their own instead of buying it from gas or electric light companies. Any person so wishing, can purchase a complete plant enabling him to make his own light as he needs it, and thus get it *at cost price.* Such plants, known as isolated plants, complete in all their details, are sold and installed by this company. Over 1,000 such plants aggregating about 500,000 lamps, have been sold and are now in operation in the United States. The installation and use of these isolated plants, mostly by individual enterprise, have involved private investments varying in each case from $500 to $50,000. No other evidence could more forcibly demonstrate—1st, that the light, as a light, *must be, and is, giving satisfaction;* 2d, that being used on so large a scale, its *economy is* firmly established; and 3d, owing to the large sums of money invested in plants by individuals and corporations, the *value of the system* as an investment has been determined beyond possibility of doubt.

It is found that the cost of the light in mills, etc., (where attendance and power are present, but including a proportion of their cost), is equal to gas at forty cents to one dollar per thousand feet, varying with the cost of fuel and the number of hours' daily use. Our records show abundant and conclusive proof of this statement.

THE EDISON CENTRAL STATION SYSTEM.

WE now offer to the public a system of lighting which has successfully competed with the best managed gas plants, not only as a means of furnishing light, but also as a business giving satisfactory returns for the capital invested.

The first distributing station built by the Edison Company was in the financial centre of New York, and was put in operation September 4, 1882, and from that day to the present time has been in continuous operation. For this station, which was designed to supply 15,000 lights, there was absolutely no shadow of precedent in the world; consequently, the station and system were essentially experimental, and cost very much more than they could be now reproduced for. Notwithstanding all these drawbacks and disadvantages, the capacity of the station was speedily reached, and an annex station has been built to supply the still increasing demand for lights. At no time has the light been furnished cheaper than gas at $2.25 per 1,000 feet, although the price of gas has been twice reduced in this district. In spite of all these disadvantages, however, this station has, for nearly three years, paid regular dividends upon its abnormally large capital, and will undoubtedly continue to be a permanent dividend earner.

OTHER EARLY STATIONS.

ON July 4th, 1883, the first station on the three-wire system was started in Sunbury, Penna. From that time until the present Mr. Edison and his co-laborers have bent all their energies to perfecting the details of the Central Station system, with the most successful results, as our present record shows.

Many of the early stations may now be called experimental stations, but all of them, in spite of the bitterest opposition, have furnished a light which has taken a full share of the illuminating business of its locality. The experience gained in the construction and operation of these stations has enabled us to construct and operate a large number of other stations, which not only furnish a light that is superior to any other, but also pay good dividends upon the capital invested. We therefore make and can sustain the assertion, that in *any moderately prosperous city or town* in the United States, a *central station can be installed* by the Edison Company that, with *proper management, will pay good dividends.*

That the Central Station business of the Edison Company is on a good substantial basis is shown by the growth of its business and its condition to-day. Where, less than six years ago, there was only one Edison station running, there now are upwards of ***one hundred and twenty-five,*** and the number being organized and constructed at the present is very much greater than at any previous time.

These stations employ, in the aggregate, over $15,000,000 capital, and have capacities varying in different cases from 300 to 40,000 lamps.

FORMATION OF COMPANIES.

Stock Basis.

THE patents (numbering over 350) covering Incandescent Electric Lighting in all its details are owned and controlled by the Edison Electric Light Company (which we will call the Parent Company), from whom all licenses to use the same must proceed. In large cities and towns, the Parent Company deals directly with Companies formed for operating Edison stations therein, taking as a consideration for the franchise a certain proportion of the capital stock of such sub-companies, and thus becoming a partner in the enterprise. In this case, the Parent Company defers its profits, as the local company is given the right to purchase all apparatus forming part of the system from the licensed manufacturers at factory prices.

CASH BASIS.

For smaller towns and villages, of 10,000 population and under, we have acquired from the Parent Company the exclusive license to form local illuminating companies, and to deal with them. Our method, however, differs from that of the Parent Company, in that we sell outright the apparatus for the Central Stations which are formed under our auspices, and do not require any portion of the capital stock of the local companies. In this case, therefore, the entire Central Station plant and its profits belong wholly to the local company.

CONSTRUCTION OF STATIONS.

THE Edison Central Stations are constructed in accordance with the given standards that our experience, extending over six years, shows are best adapted for the purpose. This experience points out forcibly that there are two elements which it is ***absolutely essential*** to observe in the construction and operation of stations, namely, ***reliability*** and ***economy.***

These essentials call for the most experienced supervision in the laying out and construction of the stations, to the end that the confidence of the public may be gained for the light, and the stations made to pay good profits on the investment.

The principles upon which Edison stations are constructed exclude any ideas of false economy.

It is a false economy which draws the line at the minimum of investment in a central station, and, therefore, we solve the problem of reliability by a judicious liberality of expenditure in the first cost of the plant, and by having the power split up into several small units instead of concentrating it into one or two larger ones.

LOCATION OF STATION.—Where steam is the only available source of power, the station should be centrally located in relation to the district to be lighted. Of course, convenience to railroad siding or water should receive due consideration in saving for transportation of coal and obtaining necessary water supply. In case good, reliable water power is available, the

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location of the station in relation to the district to be lighted need not enter into consideration so much, as any water power within a convenient distance of a few miles can be readily and economically utilized.

STEAM PLANT—ENGINES.—We have found from experience with all classes of engines that it is by far the most preferable to use high-speed engines directly belted to the dynamo. This is the only true economy for the varying load which there is in any incandescent light plant, where the average load for the entire run is 40 to 50% of the maximum. They are cheaper not only for the installation, but also for the running expenses under the conditions which exist in any incandescent light plant.

STEAM PLANT—BOILERS.—Plain horizontal tubular boilers of standard manufacture have been found to fulfill the requirements in the majority of cases, except where the economy of space is very important, and power must be concentrated within a small area, in which case sectional boilers are desirable.

DYNAMOS.—We consider it desirable to divide the total capacity into several pairs, all of the same capacity. This subdivision of dynamos enables the different ones to be shut down or thrown in as the load decreases or increases, and by having them of the same power, there is required only one set of necessary spare or duplicate parts.

COST OF STATIONS.

If we are furnished with a correct map of the district to be lighted, showing the proposed distribution of lights, we can make an exact estimate of the amount for which we will contract to put in the whole plant complete, and deliver the same in working order to the purchasers; or, if it is desired, we will furnish an estimate for the electrical and steam plant, and do the work of installing the plant for the purchasers on the basis of receiving a certain percentage upon the cost of the equipment. Should the purchasers desire to purchase their own materials, (other than the Edison apparatus), and employ their own labor to install the plant, we will furnish a competent engineer at a stipulate price per day to supervise

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and direct the installation of the plant in accordance with our method.

It will be seen, therefore, that we do not seek to bind the purchasers of a central station to accept our bids for the actual setting up of the plant, but leave them free to purchase their own materials and employ their own labor, our only restriction being that the station shall be installed in accordance with our specifications, which are the outgrowth of over six years' experience.

A central station so installed will, with careful and capable management, earn good profits on the amount invested. This statement may be amply verified from the results obtained in existing Edison stations, where good profits are being earned, and a substantial, growing business is being developed.

METHOD OF CHARGING FOR LIGHT.

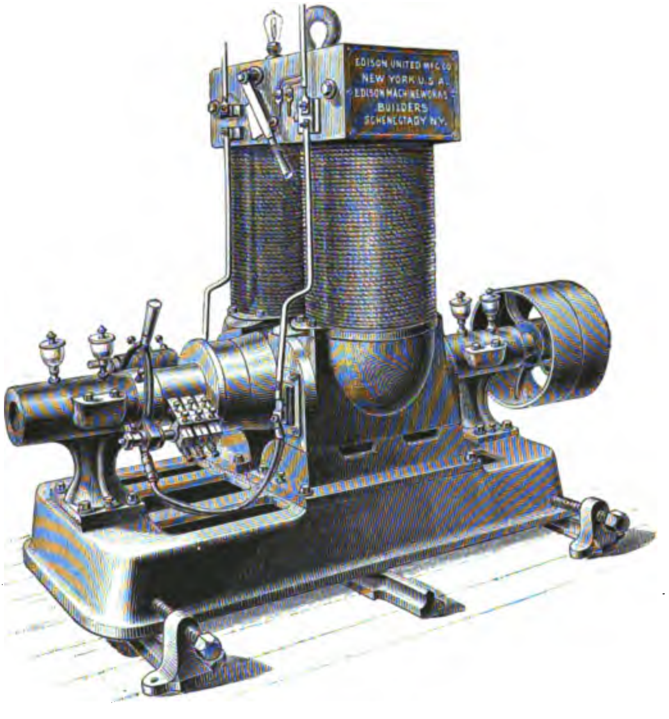
IN cities and large towns, where it would not be possible to maintain a close supervision of the lights, the Edison meter in all cases furnishes the data from which customers' bills are made out. Each consumer has a meter upon his own premises, and his bill is made out and payment required on what the meter shows.

The system of charging for lights from smaller stations, where the number of individual customers is limited, is, in many cases, one which depends upon contract with each customer at a specified rate per lamp per hour. The charge is usually from one to one and a half cents per hour for every 16 candle lamp, and at these prices the stations pay good profits on the amount invested.

ELECTRIC POWER.

THE use of electric motors, for operating all kinds of machinery, from a sewing machine up, has grown so rapidly and the demand for electric power is so great and universal, that the furnishing of power forms a very important part of the Edison central stations. The motors being used by customers chiefly during the day time, provide a profitable market for the current at a time when there is the least lighting, thus making day running of the station a means of adding largely to the profits.

Electric motive power is a positive boon to a small town or village, where there are many who would use power were it not that steam engines and boilers are too expensive a luxury for them. Put within the reach of such persons, a small machine which, by the mere turning of a switch, will run their sewing machines, lathes, printing presses, hoists, elevators, saw-mills



THE EDISON DYNAMO.

or other machines, not only cheaply, but cleanly and almost noiselessly, and the opportunity will be quickly grasped.

An electric motor run from an Edison station is the most convenient, most reliable, and most easily controlled source of power imaginable. Always ready, it can be started or stopped by turning a switch; it is only necessary to oil two bearings and all is ready, and on turning the switch there is at once a steady power, doing its work quietly, cleanly and well, and requiring little if any attention.

Manufacturers or others using small power, or using power intermittently, can get their power cheaper from a motor run from a central station than from any other source.

Any work that a steam engine can do, the electric motor can do, and in most cases will do it more satisfactorily. Those who have paid most attention to this subject, say that supplying electricity for motors is quite as important a part of a station's work as is furnishing light. In several towns central stations are being organized whose chief purpose is the selling of electric power; and there are existing stations whose revenue from motors is a very considerable part of their income.

GENERAL CONSIDERATIONS.

FROM the foregoing facts, which show very briefly the main points of the Edison system, it will be obvious that there is in every moderately prosperous town in the United States a field open for the establishment of a growing, lucrative and permanent business, and one which is ***protected in every detail*** by the ***Patents*** owned by the ***Edison Electric Light Company,*** a full review of which will be found in the "Red" book on patents, which will be sent to any person desiring a copy.

Nothing could be more indicative of the solid financial character of this business than its rapid and ever-increasing growth; and this, not as the result of a boom, but from the advantages and benefits which have been foreseen and realized by those who have first investigated and then invested.

GAS COMPANIES.

THE Central Station business of the Edison Company has already attracted the attention of some gas companies in this country whose managers have had the business foresight to recognize the advantages of combining all classes of lighting in their territory, with the result that they are making all the money there is to be made from supplying light and power in their localities. The conditions under which gas companies exist are peculiarly favorable to their also adopting the central station system of incandescent electric lighting. They are already located in the territory; their plant is fixed; fuel for electric light purposes is cheaper to them than it would be to others; they already have a manager who could attend to both branches; they know what the lighting of the town requires; they have whatever franchise is necessary for using the streets; in short, the conditions are more favorable than to any other class of business men.

We, therefore, invite gas companies to lay aside prejudices and look at *facts as they are*, and we feel certain they will see that their interests are to control *all* the lighting, heating and supplying of power in their territories.

ARC LIGHT COMPANIES.

THERE are also many reasons why arc-light companies already existing and working could advantageously add the incandescent lighting of a town to their operations. They have the station already installed, the pole lines run, the manager engaged, and, generally speaking, are in good position to operate to advantage the incandescent as well as the arc lighting in the locality covered by them. These points have been recognized already by a number of arc light companies, who have added to their dividends by adopting the Edison system and running it as well as their arc lights.

It has been attempted in many arc light plants to run incandescent lamps on the same circuit, by putting a number in series. Experience, however, has shown this to be a costly and sometimes dangerous expedient by reason of large lamp breakage, and the powerful current brought into a house or store to endanger human life, thus introducing the death-dealing element into the private household.

PATENTS.

A MOST important question arises in the minds of investors as to whether they will be protected in the use of the patented inventions comprising the Edison system. The possibility and practicability of Mr. Edison's inventions were at first flatly contradicted by several so-called electricians, but after the feasibility and commercial success of the Edison system had been fully demonstrated, they proceeded at once to unscrupulously avail themselves of the inventions which they had decried. Not only have they seized the same bodily, but they have arrogated to themselves the title of inventors of the patents so impudently appropriated. On these claims they are parading before the uninitiated public with so-called systems of electric incandescent lighting, which have in very numerous cases resulted in much pecuniary loss to the parties who have invested money on the strength of such representations.

There are now pending a large number of actions brought by the Edison Company against infringers and their licensees upon the patents which were granted to Mr. Edison and others, and which *entirely cover Incandescent Electric Lighting in all its details.* Similar suits have been brought against infringers abroad, and judgments have been given in favor of the Edison patents.

In the meantime, with the patents and decisions so far in our favor, and with the enormous commercial success which the Edison light has achieved, we beg to ask that those investors who are contemplating entering into the incandescent lighting field will send for our book on patents and carefully and impartially examine the same with a view of convincing themselves that our statements and claims are correct.

THE EDISON UNITED MANUFACTURING CO.,
65 FIFTH AVENUE, NEW YORK.

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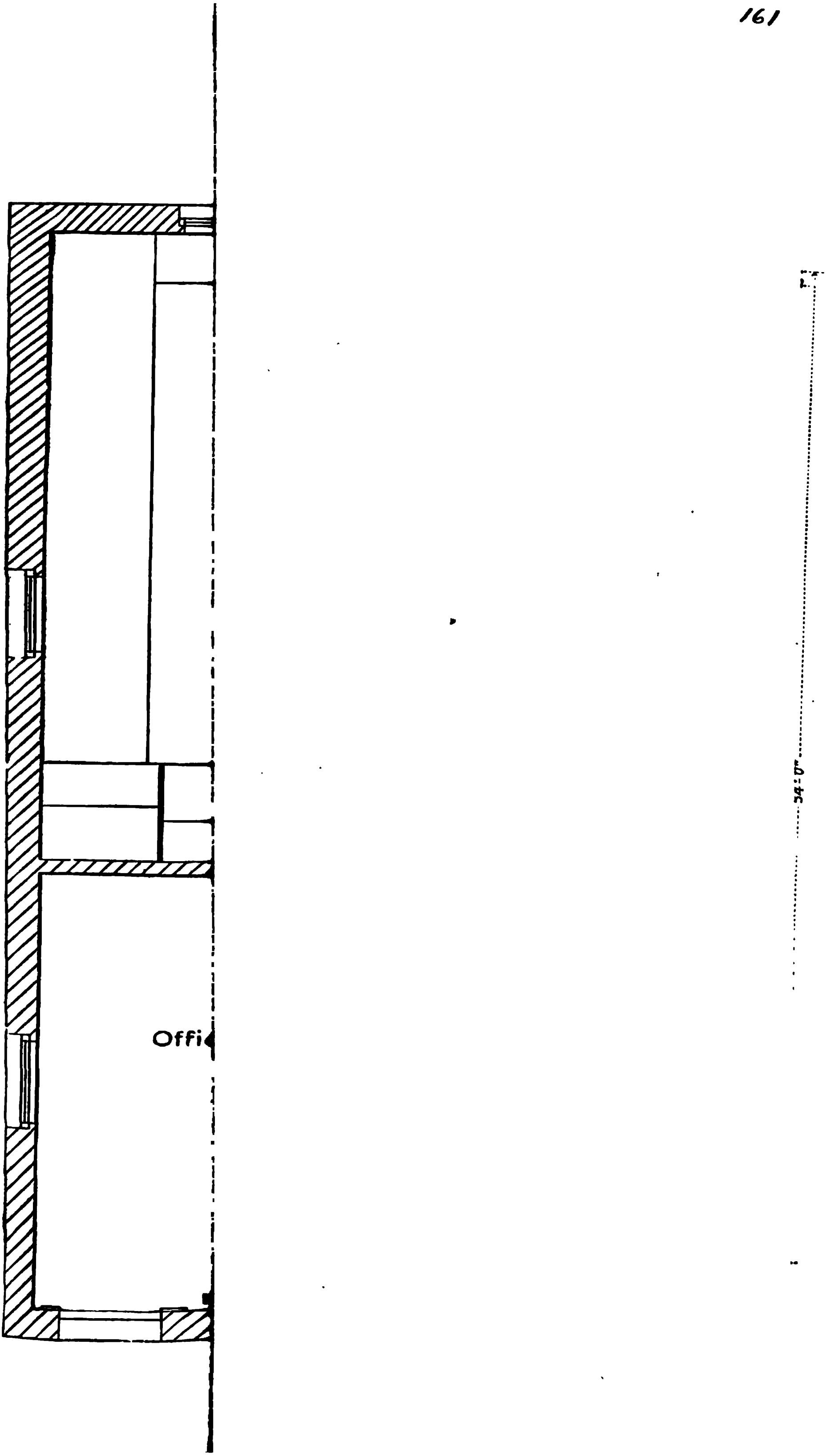

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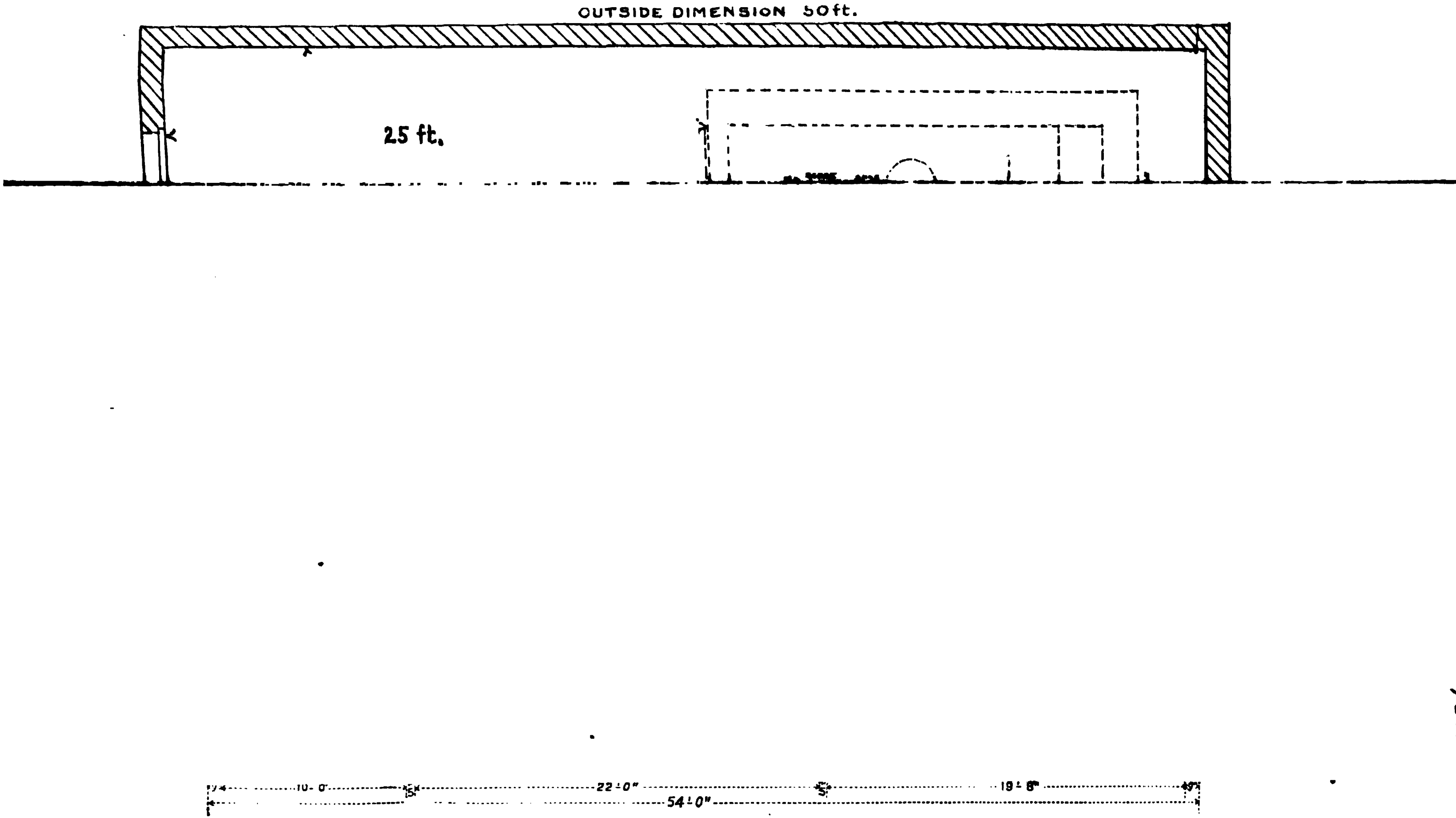
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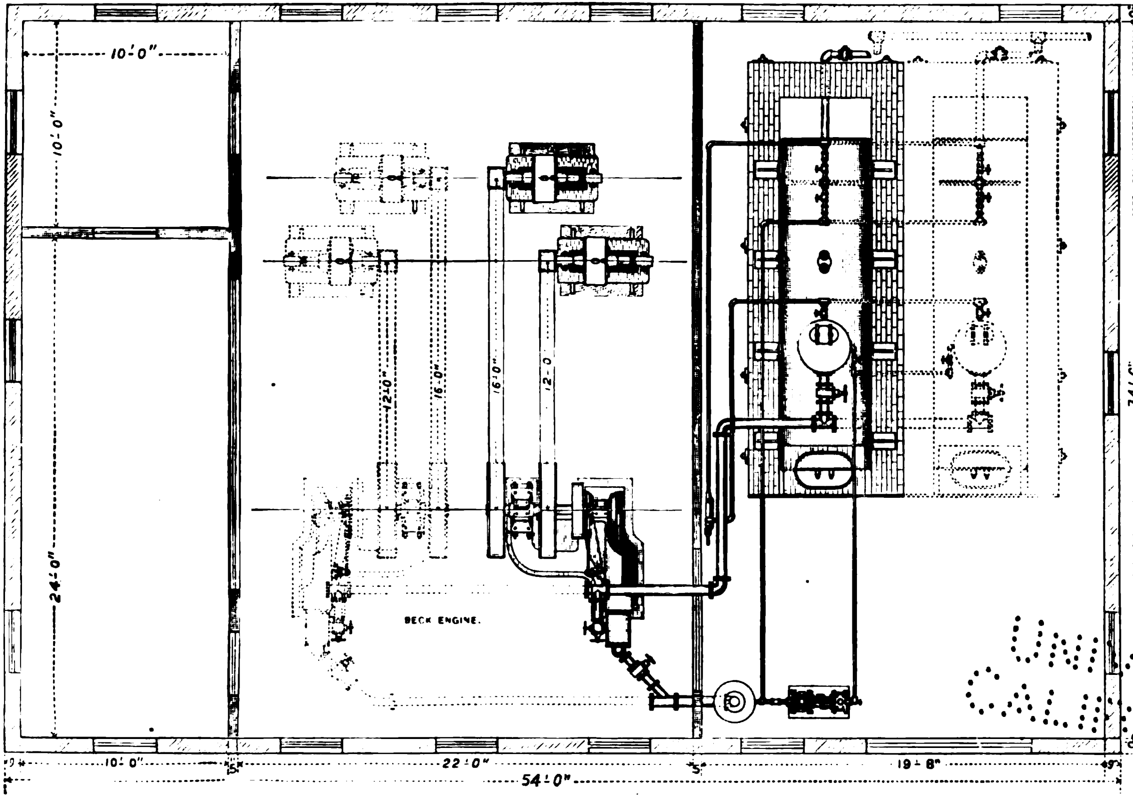
PLAN FOR EDISON CENTRAL STATION.

CAPACITY 600 TO 900 LIGHTS WITH ULTIMATE CAPACITY FOR 1,200 TO 1,800 LIGHTS



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PLAN FOR EDISON CENTRAL STATION.

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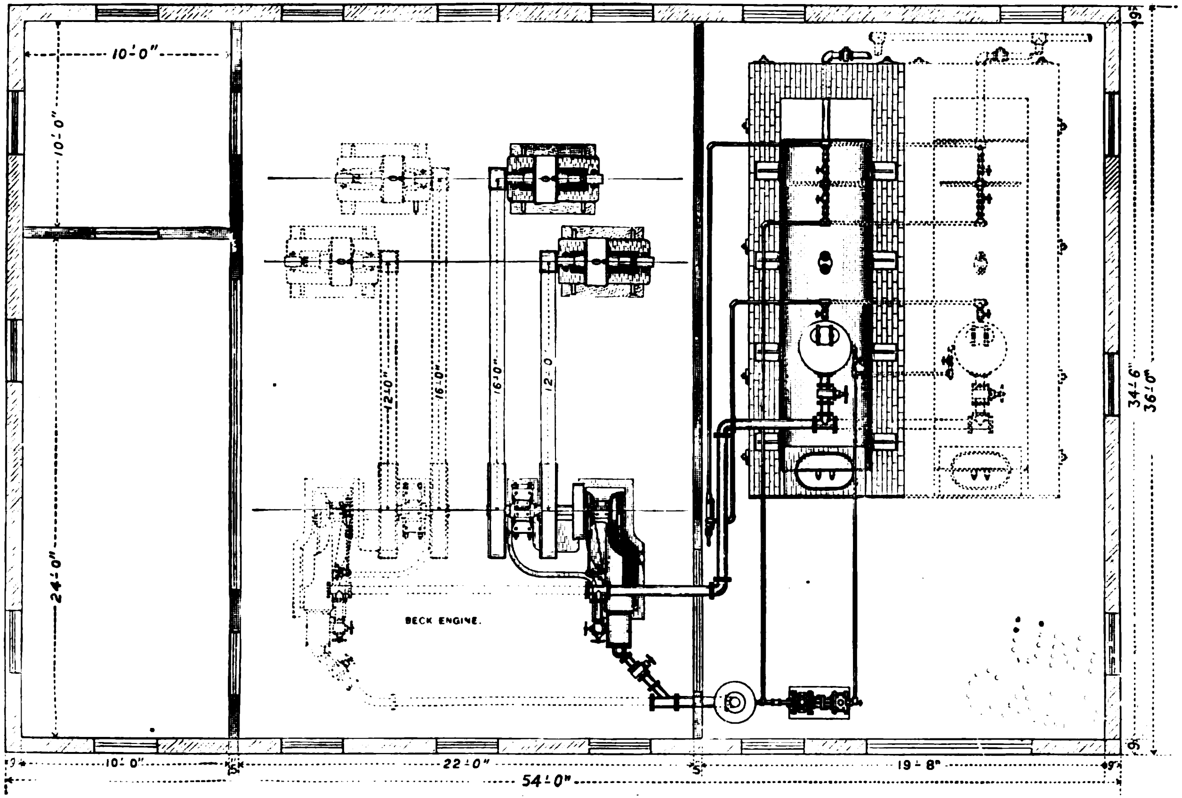

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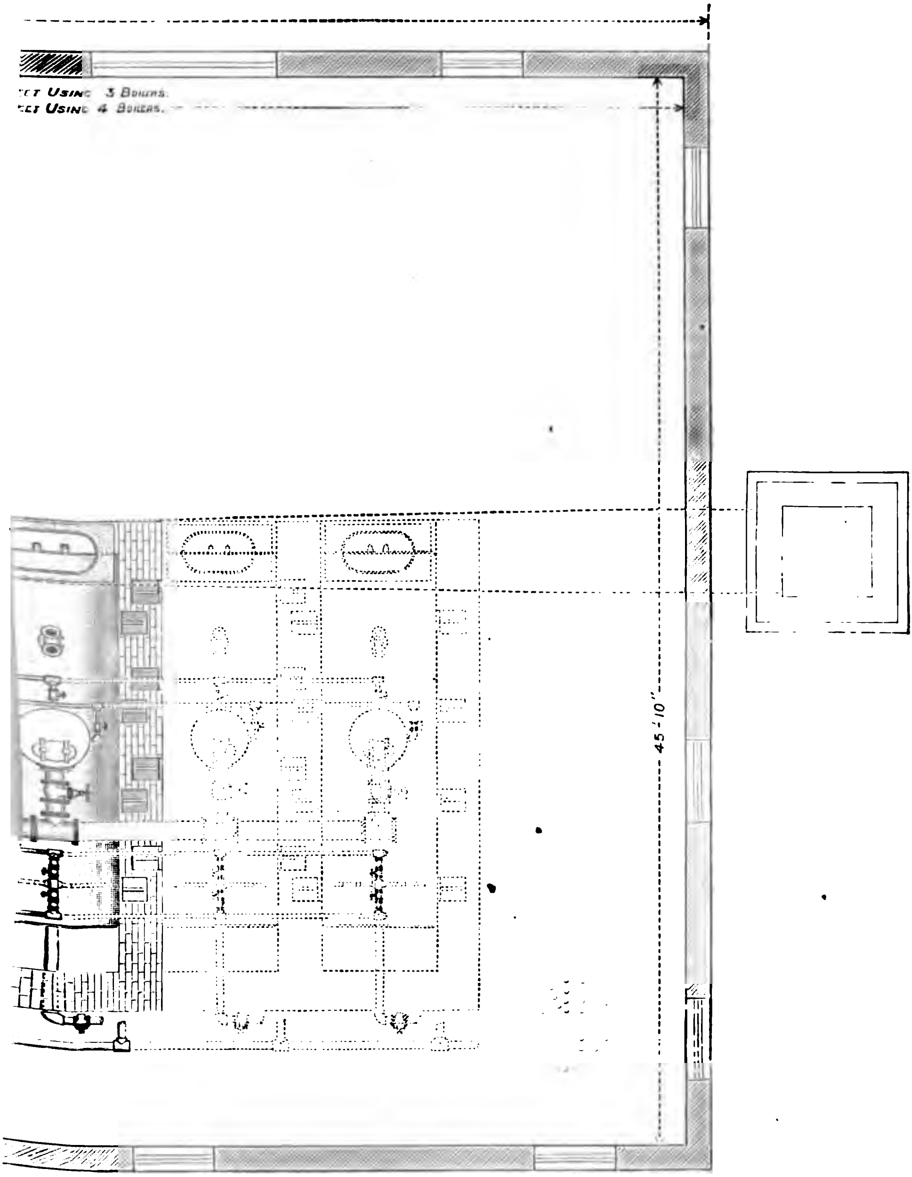

PATENTS.

The following letter which has been issued by Mr. John C. Tomlinson, counsellor of the Edison Electric Light Company, is sufficiently explicit concerning the nature of the patents involved in many suits as to afford a better understanding of the entire situation. The numerous interests liable to be affected by this litigation are of such vital importance that we publish in full Mr. Tomlinson's letter, which is as follows :

40 Wall Street,
New York,..................1887.

Gentlemen : I am advised by the Edison Electric Light Company that you contemplate building and operating a Central Station Incandescent Electric Light Plant, and I am instructed by that Company to inform you that by so doing you will infringe among others the following Letters Patent of the United States owned by them, to wit :

1. Thomas A. Edison, No. 266,793, dated October 31, 1882, on Electric Distribution System.
2. Thomas A. Edison, No. 280,727, dated July 3, 1883, on Systems of Electrical Distribution.
3. Thomas A. Edison, No. 287,515, dated October 30, 1883, on System of Electrical Distribution.
4. Thomas A. Edison, No. 274,290, dated March 20, 1883, on Systems of Electrical Distribution.
5. Thomas A. Edison, No. 287,517, dated October 30, 1883, on System of Electrical Distribution.
6. Thomas A. Edison, No. 265,784, dated October 10, 1882, on Regulators for Dynamo-Electric Machines.
7. Thomas A. Edison, No. 283,986, dated August 28, 1883, on Systems of Electrical Distribution.
8. Thomas A. Edison, No. 264,642, dated September 19, 1882, on Electric Distribution and Translation System.
9. Schuyler S. Wheeler, No. 335,099, dated January 26, 1886, on System of Electrical Distribution.

10. Frank J. Sprague, No. 335,045, dated January 26, 1883, on Systems of Electrical Distribution.
11. William S. Andrews, No. 317,700, dated May 12, 1885, on Systems of Electrical Distribution.

Suits have been instituted by the Edison Company upon these patents against Westinghouse, Church, Kerr & Co., who are acting as the exploiters of what is called the Westinghouse system (which so-called system I am informed is the one you contemplate using), in the United States Circuit Court for the District of New Jersey. Should the decisions in these suits be favorable to the Edison Company, they will at once proceed to obtain injunctions throughout the country against all infringers of their patents, and will at the same time bring action to recover damages for past infringements.

In addition to the suits referred to above, the Edison Company had previously instituted, and are now pressing suits in the Circuit Court of the United States for the Southern District of New York, against the United States Electric Light Company and others, upon the following patents: Nos. 265,311, 251,554, 223,898, 227,229, 265,777, 239,149, 239,153, 248,419, 264,698, 230,255, 266,447, 248,424, 288,318, 263,140, 307,029.

These patents are also infringed by Westinghouse, Church, Kerr & Co., and will also be infringed by you in case you erect and operate the station referred to.

Upon the determination of these suits, proceedings for injunctions and damages will likewise be instituted against all infringers throughout the country, including Westinghouse.

It is entirely impractical at the present time for the Edison Company to multiply litigations upon the same patents in different sections of the country, and they have adopted the course usually followed in such cases, of proceeding against the responsible promoters of the infringements and awaiting the determinations of these litigations before instituting proceedings against the users.

The object of this communication is to furnish you with exact information of the patents which it is claimed you will infringe, and of the suits now pending before the courts against the promoters of these infringements, and of what you may expect in case you determine to disregard the patents referred to. Having furnished you with this information and notice, you can procure copies of the patents referred to, and can determine for yourselves whether the station you contemplate erecting and the apparatus and methods you desire using will infringe the same, and you can also easily verify the statement I have made in regard to the pendency of these suits by communication with the clerks of the courts to which I have referred.

This communication is dictated by a still further object, and that is, by giving you the information referred to, to deprive you from saying hereafter when suits shall be brought against you, that you acted innocently and without knowledge of the rights of others.

(Signed,) JOHN C. TOMLINSON,
Counsellor for the Edison Electric Light Company.

THE DEVELOPMENT AND FUTURE OF THE EDISON MUNICIPAL SYSTEM:

EXTRACTS FROM A PAPER

READ BEFORE THE

Association of Edison Illuminating Companies

BY

W. J. JENKS,

AUGUST 10TH, 1887.

STATISTICS REVISED TO MAY 1st, 1888.

The Development and Future of the Edison Municipal System.

The importance and the original completeness of that greatest of Mr. Edison's conceptions, the modern incandescent lamp, are only fully appreciated when we come to realize the diversity of its applications vital to our convenience, economy and prosperity in this busy age.

We cannot fail to admire the exceeding simplicity and efficiency of the little device which transforms the energy of the dynamo into that useful heat, which under his hand kindled for the first time in the slender filament of carbon, a glow bearing a commercial ratio to the power expended, and gave him the first glimpse at a practical, business-like application of the principle on which so many had toiled in vain.

There are so many who, lately interested financially in the success of the Edison system of to-day, are seeking to gather and treasure every point of history and of recent progress, that it may be pardonable to glance at the distinction which exists between the Edison series lamp and those of the earlier experimenters.

The present Municipal lamp, in common with all of the Edison or "filament" type, is a structural unit. From the days (in 1845) when King and Starr heated a rod of carbon in the Torrecellian vacuum of a barometer tube, to 1878, the laboratories of the world had produced only pencils, sticks and wires of widely varying material, using currents of very low pressure and large quantity with the fixed idea of replacing the shining rod when it was burned away. Hence all or nearly all the early lamps were complex in their construction, and if successful would have been very expensive. Hence also, it was impossible to maintain in their adjustable chambers the high degree of vacuum essential to long life. It was further necessary to employ clamping devices or terminals allowing of expansion of the rigid carbon while practically insensible to its heat. From the mass of metal thus introduced into the interior of the chamber it was doubly expensive to exhaust the air and occluded gases. The great amount of energy which was expended in giving a little light shows that a large per cent. of the heat actually developed inside the bulb was due to the resistance of imperfect contacts, or was conducted away by the terminals, while the partial vacuum afforded a vehicle or medium for the leakage of an unmeasured proportion of the electricity around the carbon without accomplishing any useful result.

In the simplicity of Mr. Edison's conception we see all these conditions changed. The carbon itself is reduced from the brittle pencil to the flexible steel-like "filament," and with him this graphic descriptive term is original. The short thick rod, shining like a star, and in its diverging shadow lines akin to the arc lamp, stretches out to a thread and forms an arch of less specific intensity and really superior illuminating value. Its flexibility abolishes the annoying and expensive adjusting devices. As they disappear, the time of exhaustion diminishes and the vacuum improves. It becomes possible to make a more perfect electrical bond, of small size, between metal and carbon, and heated terminals are avoided, leakage through the vacuum space is almost eliminated, and the heat formerly rapidly conducted by large clamps and wires back into the socket, is held and forced to yield additional light and additional revenue.

But above and beyond all these comes the most original and far-seeing provision of all. The Edison lamp chamber is made entirely of glass, cheapened by the glass-blower's art until it forms so small a part of the cost of the lamp that when the vital and expensive carbon and vacuum have lived out their usefulness and died a natural death, the whole may be thrown away like a body from which the living principle has gone.

Still another point of phenomenal anticipation excites our admiration after years of practical work. Former students had struggled only to secure a possibility of attaining a result at any price. Mr. Edison's acute analysis of the necessity showed him that mere success as a laboratory experiment was of no lasting importance. The future of the incandescent lamp, as a factor in the civilization of the nineteenth century, depended upon the cost of a candle of light for an hour, and this in turn upon the number of candles which could be realized by a number of carbons from a horse-power of mechanical energy expended in the cylinder of the engine and the length of time this light-giving efficiency could be maintained in the carbons without breaking them.

It is evident to any thinking mind that this, in the early stage of the art when the lamp problem was solved, must have been a very complex equation, and the number of unknown quantities must have been legion. But Mr. Edison's prophetic vision seemed to divine that the steam engine's efficiency would not be greatly varied ; that the dynamo could be made to convert into electricity almost all the energy applied as motion to its pulley ; and that the proportion of loss which could be tolerated in distributing the current was only dependent upon the cost of copper, which, by reason of the abundance of the supply in nature, was simply a question of increased demand. Thus reasoning, he established an illuminating efficiency of 150 to 200 candles of light for a horse power of electricity and a life of 1,000 hours at a first cost to the public of $1 for the lamp, as the combined standard toward which for months and years he bent all his efforts. How far they were crowned with success is best evidenced by the present financial importance of the incandescent lighting industry, and by the fact that in all the multitude of present claimants to a share in the honor due the genius of a new creation, many of whom "came to scoff," and remained to imitate, no one has in any essential degree departed from this standard, nor been successful in exceeding it in application to general commercial business.

With the present facilities for economically generating currents of either high or low pressure, the problem of reducing the cost of distributing the energy produced and making available the largest proportion of it in useful light claims the best efforts of the Edison Company. It is no secret among us that for domestic lighting, within a radius of a mile or more, the three-wire system holds undoubted advantage over any method of transformation or accumulation. The frequent efforts to prove to the contrary have simply shown that the law of compensation, as applied to things electrical, never fails to raise towering disadvantages and difficulties in the path of the inventor who would seek the aid of excessive pressures and small conductors. Mr. Edison again illustrated his grasp of the situation when early in the history of the business he characterized all schemes of this kind as "merely efforts to save copper." Hence the steadfastness with which the cardinal principles of low potential, safety and controllability of each lamp have been adhered to and made the corner stones of the system with which we to-day serve the public.

But the man of one idea never covers the whole field of popular demand. There are uses to which the Edison lamp may be applied where the general methods which must govern house-to-house service would be out of place. In the lighting of streets by gas the necessity of separately controlling each lamp has proved one of the most serious drawbacks to cheap service, and the inventive skill of the gas engineer has for years vainly sought a remedy. The records of the Patent Office show that in one case at least great hopes were cherished of the future of a plan of connecting the posts of an entire city by small wires, and lighting and extinguishing the system by automatic electric burners operated from the gas works. The city authorities of Providence, R. I., permitted an experiment with this method, and no money was spared in the effort to show its feasibility. Scores of difficulties arose and finally compelled a return to the tedious and expensive plan of two daily visits to each post. That which is demanded in the ideal public service as a prime necessity, a means of lighting or extinguishing districts or wards of cities, or suburban towns, from one central point, instantly at any time, electricity alone can supply. In such a work, another thing to be desired is the placing of the government of the system as much as possible out of the reach of the individual. Still another is a ready means of varying the illuminating power, and consequently the expense of individual lamps to meet the requirements of all conceivable situations. Here Mr. Edison has taken his filament lamp, and retaining all the advantages of light-giving effects, economy and longevity, which have been described, has modified its construction so that instead of using a small fraction of the total current to the system and the entire pressure, it takes the entire current and a small fraction of the pressure. In this respect alone it resembles the lamps of the early experimenters and admits of placing a great number in series, raising the potential to a degree only limited by safety in handling, good insulation and reliability in the dynamo, thus covering great distances with small conductors. Let us sum up then THE ADVANTAGES ENJOYED BY THE MUNICIPAL SYSTEM at present, for the well-defined and strictly limited uses to which it seems proper to apply it:

1. *High efficiency of the 1,200-volt dynamo.* It is only just, in noting this point, to state that no exact dynamometer measurements have been made of power expended. It is certain, however, that the armature resistance in the larger sizes is less than 2% of that of the outside circuit, and that only 3% of the total output of current energy at the brushes is absorbed in vitalizing the magnets. Hence the commercial efficiency cannot fall far short of 90%, and may even exceed that high standard.

2. *Small loss with small wires.* It is generally conceded that the correct principle is to make the extra outlay in running expense occasioned by the loss in the wires equal to the interest on the first cost of the copper. As is well known, the feeders, mains and interior wires of central stations are usually estimated to allow a total maximum loss in pressure of from 12 to 15%. A little reflection will show that this loss, with the full load for which the system is calculated, only occurs for a short time in each 24 hours, in most cases only the fraction of an hour. The average loss actually sustained during the term of a run, or during 24 hours, is probably as low as 5 to 7%. But with the Municipal, as applied to streets, the load is constant, and the loss, whatever it may be, is prolonged for a considerable number of hours. Hence, unless the conductors be of sufficient size to reduce the loss to a small per cent., it will more than balance, every 24 hours, the interest on the copper composing them.

Fortunately for the greatest economy, this loss can be accurately computed.

When hard drawn copper wire can be bought for about 20 cents, as at present, in any required quantity, and power by steam usually costs from $40 to $60 per year per horse power, it is economy to keep the loss down to 7 to 8%. Even with this small drop the wire is by no means excessive, a No. 12 Edison gauge (almost exactly corresponding with a No. 12 Birmingham) allowing of a circuit of 5 miles in total length. In the case of the Municipal another factor comes into this calculation of loss in pressure. The fact that the E. M. F. of the dynamo is strictly limited to 1,200 volts, and that the voltage required by individual lamps has been brought to as low a point as is consistent with good light and life, makes it evident that while, if we lose but 5%, or 60 volts in the line, we may attach to each circuit, say 57 lamps of 20 candles, if we were to lose 16⅔%, or 200 volts, we could run but 50 lamps. Thus in a large system we should considerably increase the number of circuits, and hence the cost not only of copper, but of poles, fastenings, labor, station apparatus and inspection. From the use of small wires we get facility of making attachments to existing poles or other structures, ease in securing rights of way, and light construction work generally.

3. *Very high lamp efficiency.* It is not within the province of this circular to discuss the essentials of success with lamps giving a maximum of light with a minimum of power. There is one feature or characteristic of our system which cannot be emphasized too strongly or rehearsed too often. It is that an incandescent lamp, unlike any other light-giving apparatus devised by man, is an unalterable unit in its capabilities. It presents a certain definite resistance to the passage of the current at all times when doing the work for which it was created. Hence, that it may give the total number of candle-hours for which it is made and guaranteed, it must be supplied with current at a uniform pressure. If this is lowered, the ratio of power absorbed, to light given, is increased; if raised, the ratio of power decreases, but at the expense of its life. It is entirely within the bounds of truth to say that the failure to secure uniform pressures at

the lamps of our central station systems, to whatever causes it may be traceable, is the hidden spring of more unnecessary lamp breakage, more fault-finding of consumers, more discontent among managers, and more complaint to the parent company than occur from all other causes combined.

The Municipal plan offers a method of entirely avoiding this bugbear of all other systems of distribution. With good firing, that is to say, uniform steam pressure, a good engine, and a constant load on the dynamo, there is no reason for material variations of E. M. F., and as the only normal process of change in the resistance of any circuit actuated by this constant E. M. F. is the extinction of a lamp, it follows that when, for instance, one of a series of 50 lamps expires, there can be an increase of but 2 per cent. in current forced through the remainder, and this only until an attendant at the station has inserted a compensating resistance, or an inspector replaced the exhausted lamp. Hence in practice, it is common to run several hundred lamps of a street system all night without a change in the regulator of the dynamo, and in nine-tenths of the circuits, without the variation of an ohm in the adjustable resistance with which each line is provided. As one result of this nearest approach to uniformity of pressure ever obtained in the experience of the incandescent industry, the life of the lamps is something phenomenal. The first standard was of rather lower efficiency than the regular central station type. With these, records of 3,000 to 5,000 hours were not uncommon, and as high as 5,000 to 7,000 hours have been observed. The very ruggedness of the carbon has led to carelessness and abuse. Lamps of the second type employed, requiring about one-third less energy, lasted from 1,500 to 4,000 hours. In the new lamp, with its still higher service and bringing down the power one-quarter more and increasing the output to 240 candles to the electrical horse-power, we still get from 1,000 to 2,000 hours.

4. *Cheapness and Reliability.* The first forms of apparatus for the control of individual lamps were shunt cutouts, expensive, and like all mechanical devices exposed to the weather, unreliable in action. Electrical difficulties early appeared. The lamp, at the breaking of its carbon, usually

created within itself an arc which the cutout was powerless to arrest, and which destroyed everything in its way. When for any reason this arc did not form, it was found that the high pressure brought to bear upon the lamp before the circuit opened would pierce a thickness of insulating material, and this simple safeguard, applied in a very small space in the hood cutout or suspended socket, has greatly reduced the expense of installation. Extended laboratory trials showed that when this destructive arc was formed, it must also be suppressed inside the lamp. Three methods have been tried, each involving in experimental work the destruction of thousands of lamps. The first was a smothering of the arc in the stem by obliging it to eat its way through powdered non-conducting and non-combustible material. In a majority of instances this operated successfully; in some it failed. The second was the fusing together of the leading wires, either in the vacuum or in the stem. Other experimenters were working on this same idea, and like ourselves, with varying success. Probably 95% of the lamps of the best pattern were thus satisfactorily protected—the other 5% still being faulty. During the progress of these investigations a committee was appointed to co-operate in reaching a standard. The labors of two or three active members were continued for nearly a year and a half, and their reports would fill a small volume. After exhausting their ingenuity, and a large share of their patience, as well as the inventive resources of the Lamp Company, they were compelled to appeal to Mr. Edison for his personal assistance. As usual, it was quick and decisive. A third principle was invoked, and all difficulties vanished. As now constructed, the Municipal lamp has a short third platina wire between the regular terminals. Outside the vacuum chamber, in the stem, this connects with a fine iron wire holding a phosphor-bronze spring in tension. At the instant of the formation of an arc usually near one end of the carbon, the current divides between the opposite terminal and the middle conductor, the latter taking a sufficient volume to instantly melt the iron wire, liberate the spring, and by short-circuiting the lamp within itself cut the arc and even prevent the temporary exhibition of fireworks which the most reliable of former devices permitted. Several minor arrangements of which time forbids even a description make the action of this novel mechanism positive, and founded as its action is upon an electrical law, applied by Mr. Edison to the potential indicator five years ago, and by methods on which he has broad patents, it is exceedingly gratifying to see the most serious difficulty which has ever delayed the rapid advance of this useful system entirely removed.

It might be interesting to consider in some detail the numerous devices and methods created and worked out to a standard to prepare this flexible principle for the varied applications already foreseen.

Among these devices are a special base frame to secure that prime necessity, high insulation of the dynamo; switchboard intended to be placed at a distance from the wall allowing of access to the rear, and such attachment of conductors as will protect all connections from accidental contacts, and the attendant from shocks; a self-contained section of board for each circuit, comprising lightning arrester, peculiar fusible double pole cutouts, ampere meter with automatic alarm to call an attendant in case of sudden variation of candle power on any circuit, a small bank of resistance lamps which when required burn at low candle power, and cord and plug connections making it easy to attach each circuit to any dynamo; volt meter reading from 400 to 1200 volts; an automatic open circuit and ground detector; numerous patterns of posts and attachments, brackets, insulators, hoods, lanterns, cable suspending devices; methods of attaching to trees; mast arms, distributing boxes, pole cutouts, insulating and moisture-proof sockets with automatic short-circuiting and film cutout appliances; ceiling attaching cutouts and special insulators for interior lighting; devices for tunnel and other railroad work.

No effort has been spared to utilize the practical lessons taught by the experience with the first few plants, and in the necessarily slow and tedious experimental labor of bringing every device to a high standard of excellence before special effort was made to place it in the hands of the public, every creative facility afforded by the laboratory of Mr. Edison, the Lamp Company, the Machine Works, and last and

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especially Bergmann & Company, has been drawn upon freely.

To give some idea of the care with which the foundations have thus been laid for well-defined standards, looking to a comprehensive business, a series of about fifty blue print diagrams has been prepared, minutely showing these special appliances and methods of their application, and a pamphlet of between 30 and 40 pages of rules for installation and maintenance.

The Municipal system is considered by the parent company one of the most promising departments of our work, and extraordinary expense and labor have been incurred in standardizing what will prove one of the most useful servants of the illuminating manager, or the city doing its own street lighting.

A concise statement of the installations thus far made is important. One of the series of diagrams is to be devoted to a memorandum of work done. It now shows a total of 15 plants in operation, some on series circuits according to our plans, some in multiple series with special cutouts for each lamp. The total capacity of dynamos thus far actually operated is about 10,000 lamps of 20 C. P.

This is but a beginning, and perhaps a little general information about the few individual stations may not be without interest.

The Lockport (N. Y.) plant was started in March, 1885, by the Lockport Gas Light Company. This system enables them to operate 139 16-candle lamps on the outskirts of the city, beyond the reach of their gas mains. The manager writes under date of July 11: " The machine we now have " has been running since January, 1886, and I should judge " the commutator good for two or three times that run now. " The lamps are giving long life."

At Portland, Me., amid the most extended series of experiments which has been found necessary to standardize the new system, and various changes of apparatus during the early months of the business (the fall of 1885) 175 32-C. P. and 75 16-C. P. lamps have done service on the streets, and from 75 to 200 lamps of varied powers in interiors, for nearly three years. In spite of the defects in the early devices here in use, the system has done creditable work.

The Lawrence, Mass., plant was started December 24, 1885, and injured the reputation of the Edison system by placing 10-candle lamps on posts 15 to 16 feet high. Of these, 435 are operated until 11:30 o'clock, and of 16-candle power 117 are running all night.

The fourth plant, at Jacksonville, Fla., has run successfully since January, 1886. In April it was purchased by the Citizens Gas Light Co., and has always been used exclusively for the lighting of stores, the circuits being attached and detached at stated hours at the station, which is 3,000 feet from the nearest lamp. There are 20 10-C. P., 91 16-C. P. and 60 32-C. P. now in use. The manager writes: "In general the system has given good satisfaction, and compares very favorably indeed, with the newly-installed Sawyer-Man lights." The dynamo capacity was, at the outset, limited to 150 20-C. P. lamps, but was doubled a year ago. It would hardly be expected that the Gas Company would push this plant very vigorously within the field of their gas plant, yet they have met competition successfully. Late advices show a rapid extension of this plant in consequence of a complete breakdown of the Sawyer-Man system.

A letter from E. W. Rollins, President of the Colorado Electric Co., dated July 22, says: "The City Gas Inspector " now advises me that our light is giving entire satisfaction, " and I am very much gratified." Here the Brush Co. did their own construction. It need not be surprising that some serious difficulties have been overcome. At present 900 lamps of 20 candles are burned on moonlight schedule (8 hours per day average). Portions of the city are lighted with arc lamps from the same station.

One of the most interesting plants is that of the Lachine Canal, Canada, the property of the Government. This is the third year of its operation, and it is found that 50-candle lamps, 130 feet apart, give excellent results on the dark surface of the canal and surroundings. The plant is run by water, and including buildings, wheels, shafting, etc., cost $15,000, or $83 per lamp; part of this outlay being for a wheel and shafting, from which is run the Harbor Commissioners' arc plant, and for spare wheels and shafting. The capital rightly chargeable to the municipal plant does not exceed $11,000, including the proportion for building and power. The running expense for the canal season, 11 hours per day, including 10% depreciation, is $3,700. The only portion of the apparatus which has given trouble is the cable, of which there are several sections under water.

Seattle, W. T., had May 9, about 150 lamps in operation, 16 and 32-C. P. Only a few are applied to streets. For interiors, 12 hours per day is the average. The electrician states, under date of May 15: "The system as a whole gives good satisfaction."

Tacoma, W. T., operates 71 street lamps (15-C. P.), an average of 10 hours a day. In interiors, mostly stores, about 50 lamps are reported placed May 15. The plant has been in operation since January 5, 1887.

It is proper to say regarding these existing plants, that all which have given immediate and uniform satisfaction have been installed under the direction of inspectors experienced in handling this system, and that one of the most reliable men in the employ of the company has spent nearly a year on the Pacific coast establishing proper standards of construction.

Some instances of exploits now culminating may be mentioned to show that there will soon be several more creditable examples of the municipal methods scattered over this country, and one at least across the ocean.

A. J. Lawson, representing the company in Canada, says, under date of July 25:

" I expect to place a 200-light plant in the city of Hali-
" fax. I am also trying to secure its adoption in the city of
" Winnipeg with some prospect of success. Two hundred
" lights are being placed in Vancouver. One mill takes
" about 50. This is situated at a distance of four miles
" from the Central Station, the outgoing and return wires
" thus making the circuit eight miles in length."

Attica, Indiana, started August 5th, 1887, with a capacity in dynamo of 200 20-C. P. lamps.

The Illuminating Company of Rochester, N. Y., have lighted certain wards in the outskirts of the city, where oil has, up to this time, been used. A few arc lamps are found on the principal streets within this area, but about 830 kerosene posts have been dismantled, and to them extensions applied elevating the 20-C. P. lamp to 12 or 13 feet above the pavement. Something like 150 miles of wire, and from 1,000 to 1,200 poles were required.

After an intelligent and painstaking investigation of the numerous systems whose agents clamored for a hearing, Prof. Fujioka of the Department of Electrical Engineering of the Imperial College, Tokio, Japan, purchased a 200-light plant, and the installation will be made by one of our men who also places the three-wire system by which the palace of the Mikado will hereafter be illuminated.

The field for this system, which goes so far toward overcoming distance, is enormous. Of course, its most important application will be, as it has been, to

STREET LIGHTING.

The fundamental principle of all artificial lighting is an even distribution.

When, in 1883, at the early dawn of central station illumination, the Edison Company sought to demonstrate their ability to light large interiors by contracting to equip the entire Louisville exhibition, a most serious question arose as to the degree of brilliancy or standard of light required. The gas companies at first estimated 7,000 five-foot burners, and on further investigation decided that they could not guarantee a result with less than 12,000 to 15,000 lights. In these estimates the United States Electric Light Company computed that it would probably take 1,000,000 of their lamps. The arc companies were afraid to attack the problem of a good distribution over 14 acres of floor space at the high standard set by their powerful light, and declined to compete. The engineer representing the Edison Company, in his analysis of the situation, considered the fact that he had, during the underground construction in the First District in New York, found an incandescent lamp of 8 candles to be, on account of its perfect steadiness, fully equal in value to a gas jet of nearly twice its power, so easily is the vision disturbed by the fluctuations of a light flickering in the wind or shimmering through heated vibratory air waves.

Guided by long experience in the problems of the distribution of light, realizing that success or failure hinged upon the correctness of his premises, he fixed upon a golden mean as a unit of candle power in the use of the new electrical agent, and, laying accurate plans for the work without time for experiment, made so perfect a demonstration of the value of the sixteen candle unit of light that the second year's installation did not change the power or location of a single lamp. The result of this early success shaped the methods of St. Louis and New Orleans, and its fruits have appeared in every subsequent central station. Had a single 32-candle lamp been placed in the exposition building the uniformity of distribution would have been marred, a higher standard demanded, the expense doubled, and the eye, adjusting itself to the new conditions, would simply have received the quantity of light necessary to clear perception and been no better satisfied than before.

Here then we start from a great underlying principle. As beyond the point of reasonable distinctness, we judge of relative values in illumination only by comparison, when an intense or false standard is set up, the eye is not satisfied unless all the lighted area is raised to correspond, and if good distribution and equality is secured the expense becomes serious.

With the recent wholesale and in many cases reckless reduction in the price of arc light service to the public there is a growing tendency to use powerful lamps, at least on the main streets of towns and cities, no matter what the cost.

That we may somewhat clearly appreciate the expense thus saddled upon many cities of small size as well as large towns, I quote the statement of President Clark, of the Lawrence (Mass.), Illuminating Co.:

" The experience of Lawrence points a moral in street " lighting. The city is now poorly illuminated, it is true, " mostly 10-candle lamps being used. But though our " population is 38,800 we are expending only $8,000 a year " for light. We are about to endeavor to secure 50% more, " or $12,000 and double the candle power. Then we shall " be creditably lighted at a cost of $0.31 per capita. Salem, " only 28,000 population at the last census, pays $30,000, or " $1,07 per head for arc lamps. Worcester, with 70,000 " people, pays $60,000, or $0.86 for each man, woman and " child. Thus the arc lighting companies have encouraged

" an extravagant standard, which in many cases cannot be " supported, but which, once fixed, it becomes difficult to " recede from."

By a large outlay a well-distributed light can thus be had over the more important areas, but by far the larger portion of the territory, where this excessive unit represented by the arc standard is not demanded, is left for the smaller powers. It should be borne in mind that in making this statement we are reflecting popular clamor, not scientific result. The public eye is dazzled by the glare of the arc light, and the disadvantages of poor distribution cannot be forced upon the judgment of municipal authorities. After all, the Edison central station should not be the sufferer by reason of this transitory love of show or desire to outshine another. Whether shown by individuals or municipalities it may be made the spring of rivalry which the watchful Edison manager observes and quietly attaches some arc lamps to his three-wire circuit or his Municipal dynamo, or, if the demand be sufficient, buys an arc light machine and starts a series circuit. Thus Laramie has done, with results reported to be gratifying. Thus Lawrence, Mass., did for two years, and has installed nearly fifty lights with success. Thus Scanton and Harrisburg were forced by popular demand to do, and thus Williamsport and Atlantic City find to their material advantage. Brockton suffered the arc business to be started by a syndicate of capitalists (who, without practical knowledge of the electric light industry, recognized the commercial significance of a popular demand), and afterwards purchased the plant at a price yielding the promoters a handsome profit. Thus others have done and others will do as the call for a higher standard of light in interiors and on streets grows louder year by year.

It is in combination with the arc that the Municipal thus finds to-day its most open field, and thus connected may achieve its most marked victories. But a few station managers consider that a given power expended in Municipal lamps yields a better light than in the arc, despite the disadvantages of loss of actual candle-power. The best arc lamps, nominally 2,000 candle power, show perhaps 800 candles. Assuming this as the average, the electrical energy expended

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(50 volts and 10 ampères) will furnish in the new Municipal lamp 167 candles, or between 8 and 9 lamps of twenty candles each. At the February session of this convention, one of the most practical of the speakers, who has given this subject very careful thought, stated that with four lamps of 32 candles each, he could discount in practical value and equality of distribution the best arc lamp. We have, according to this mode of computation, an advantage of about 23% in the power expended, and a considerable gain in expense of attendance. The experience of most cities has been that only 2½ to 4 gas jets were displaced by each arc lamp, and it is certain that we can double the well-distributed volume of gas light by the use of a like number of 30-candle lamps. At the rate of $30 per post per year for every night and all night service, this would amount to 33 cents per night for 120 candles in four units, which is certainly a low price for the one arc light which is in many ways outdone.

In the report made by Prof. Preece to the municipal authorities of London on the value of the arc lamp as an illuminator, the showing is less favorable than by our illustration. He found that the mean average intensity of the Brush lamps actually in use was but 400 candles; that the gas of nominally 14 candles really yielded 10 candles; and that Edison 16-candle lamps gave about 12.

On the basis of these low powers, which bear to each other almost precisely the proportions just assumed, he reported that an arc would really light 172 feet of street, and an incandescent 60 feet. That is to say, for all practical purposes three incandescent lamps of 20 C. P. each were found to do as much and as satisfactory work in street lighting as one arc lamp. In order to test the cost of producing these small lights, Mr. Preece conducted experiments at Wimbledon for six hours nightly from the 21st of March till the 21st of June. The engine used was not economical, but the report stated that without doubt an installation of 400 lamps of 20 candles could be operated for two-tenths of a penny per lamp hour. Thus burning eleven hours nightly, twenty-three nights each month, the cost would be about $12, with an output of twice the light given by gas. He therefore pronounced the incandescent lamp decidedly prefable to the arc.

The Brockton station has been quoted as having had an arc light experience. After three years and a half of operation the Edison plant was committed to the charge of the parent company for renovation and extension. The purchase of the arc plant was the first fruits of this policy of enlargement. The second move secured a contract for all the street lighting outside of that done by the arc system, thus displacing 60 gas and 290 naphtha burners by a like number of 30, 20 and 15 candle Municipal lamps.

The importance of this subject justifies a quotation from the proposition made to the Brockton City government, acceptance of which followed careful inquiry by a joint committee from the Aldermen and Common Council, and a visit to the plant operating 250 lights in Portland, Maine. Among other features occur the following :

"We will, upon obtaining permission to do so, erect our " lines and attach our fixtures to the present city lamp posts, " or at our option to the wooden posts carrying our wires.

"We propose to supply light from sunset to 12:30 o'clock " (a half-hour later than at present) on twenty nights in each " month, and on the remaining nights until one hour after " the rising of the moon.

"We also propose to use our instantaneous control of " the electric system to the advantage of the citizens by " lighting the lamps at any time before 12:30 o'clock, when " a sudden shower or storm may arise, or for the full time of " average running during evenings when from any cause the " moon does not give its expected light. In short, we propose to light the city suitably and efficiently within the " hours specified, and to supplement any failure of the " moon to conform to the anticipations of the almanac. We " will also agree to light such portions of the city as may be " desirable at any time during the night, in case of a serious " fire, provided the Fire Department will cause a suitable " gong to be placed in our station to notify the engineer of " any such necessity."

"We will contract to furnish everything which may be " necessary in way of machinery, lines, attachments to available existing posts, lanterns and lamps, and supply light

" for two years, from May 1, 1887, in accordance with the " above general specifications, at the following rates per " year:

" For each 30 candle lamp, $22 per post ;
" " " 20 " " 18 " "
" " " 15 " " 15 " "

" The amount due us to be paid in monthly installments.

" We will, during the first year of this contract, place any " additional lamps which may be required at any location " within the municipal limits, where six new lamps or more " can be reached for each mile of poles necessarily erected, " at the above prices."

In this connection we have made one of the most interesting estimates yet suggested. A town of 8,000 or 10,000 people five miles away is lighted by naphtha. An outlay of $10,000 (not including power) will construct lines and equip a system of 150 lamps of 20 C. P., and at the low figure of $15 per year light till twelve o'clock (moonlight schedule), the profit would be 8½% on the outlay now required. This may be regarded as the minimum of business which could profitably be done thus at long range, at anything like naphtha prices, but all the figures we have had occasion to consider point to easy competition with gas where a volume of business can be secured, and where anything like the same light will be accepted.

The gist of the matter then is that where a surplus of power exists a municipal department can be profitably added to an existing Edison business, and that it will not only serve the outlying wards of a city, but the suburban streets, or neighboring towns several miles away, where gas prices can be secured.

In addition to regular public street service, applications are often received for private lights from the same circuits at driveways, over verandas, above the walks of gardens, public parks and similar locations. In cities where seashore or mountain visitors are numerous high prices may be secured for this service during the summer months.

Railroad stations, bridges, warehouses and yards may often be profitably lighted by special circuits operating stated hours.

The Municipal system was devised by Mr. Edison to meet the problem of lighting one of the cañons of the far West. The original conception therefore covers its special adaptation to economical illumination of tunnels, caves and mines.

In structural or ornamental lighting, where the fancy is to be pleased as well as a necessity to be met, the peculiar lines, groupings or decorative clusters heretofore formed by gas jets or candles, can be made up of small Municipal lamps, in a long series needing but one wire. Festoons, scenic or picture illumination, signs, arbors, arches, decoration of parks or pleasure grounds, hotel piazzas and pavilions, all are within our scope. A special lamp of five candle power, recently devised for these and for mining purposes, can be operated in circuits of 135 to 165. By a simple coloring process the most varied and beautiful effects may be secured. In all these special applications, where a reasonable watchfulness is necessary or can economically be maintained, peculiar devices have been worked out for balancing and government of circuits.

INTERIOR LIGHTING.

The difficulty of supplying the call for light from the territory outside the ordinary limits makes the demand the more urgent and noticeable. Hence, when a medium is secured capable by any means of overcoming distance, the temptation is great to attempt to use it with little regard to the dictates of prudence. In cases where a contract system can be profitably entered into, and one or more circuits of lights placed in stores, to be disconnected from the station at stated hours, it may be advisable to effect such an addition to the business. The extreme simplicity of the devices and method of wiring should justly entitle the proposition to a careful hearing. The one condition most strenuously imposed should be that no change of position nor other interference would be allowed, and that the manipulation of the customer must be restricted to the replacement of an old lamp by a new one, in a manner specified. No use of municipal lamps in a residence, where they will come within the reach of children or servants, should be considered under any circumstances. The system has an ample field without thus subjecting it to conditions foreign to its legitimate intent, and under which it is likely to prove a source of danger and discredit both to the local company and the Edison interests at large.

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INCANDESCENT LIGHTING BY HIGH POTENTIALS:

A PAPER

READ BEFORE THE

Association of Edison Illuminating Companies,

—BY—

W. J. JENKS,

FEBRUARY 8TH, 1888.

INCANDESCENT LIGHTING BY HIGH POTENTIAL SYSTEMS.

The history of the electric lighting business, from the first successful commercial experiments ten years ago to the present, records a systematic effort in greatly varied directions to reduce, as far as possible, the cost of conductors in distributing current over wide areas.

Those of us who remember the announcements of Mr. Brush's progress from time to time in securing three lights, five lights, ten lights and finally forty lights upon one arc machine, recollect also the general satisfaction with which the progress of his system was regarded, in view of the fact that the mass of the copper conductors required to carry these long circuits was not increased in proportion to the distance thus covered.

Many of the managers of stations placed within later years, not satisfied with the capabilities of single dynamos of from 2,000 to 3,000 volts each, have been disposed to couple two and three of these machines in series, and thus secure 4,000, 5,000 and sometimes 6,000 volts E. M. F. This has been regularly practiced in Albany and Detroit, where two sixty light Brush dynamos have been operated in series on circuits of 15 to 25 miles. In the majority of instances the careless way in which arc light construction was at first carried on resulted in the breaking down of the insulation of conductors by these high pressures.

In some of his long distance experiments on the transmission of power, M. Deprez called to his aid still higher potentials, and even speculated on the use of 20,000 to 30,000 volts in order that distance, for the transmission of large powers, might be as far as possible annihilated.

The remarks of several enthusiastic speakers before the last session of the National Electric Light Convention, outlining the easy transference or transmission of the enormous energy of Niagara to New York and other centers where power is expensive, involving a right of way for conductors so fraught with danger that a death line must needs be drawn, over which no one should pass, have excited in most conservative minds only amusement and distrust.

While it is true that electricity is not only the most potent but the most servile of all the vast forces of the universe which are made subservient to man's will, it is no less true that following the great natural laws governing the distribution of energy in other forms, it is at all times quite as diligent to escape our control. If we realize this, and seek to learn lessons from the experience of the ablest mechanical engineers, we shall quickly come to make a radical distinction between "transmission" from point to point, or from a source of energy, and "distribution" though the mazes of a system of supply diverging from a centre or reservoir. In transmission, thus understood, we use in every department of applied mechanics, high potentials.

In the construction of the foundations of the Brooklyn bridge it became necessary to transmit gas under a pressure of 45 pounds to the square inch, a feat unprecedented in the history of the industry, and utterly impracticable except for specific uses, in connection with proper reducers in distribution, and under the watchcare of competent engineers. A high pressure gas system is now going under ground in New York, to be operated by the use of potential reducers or regulators, at the house service.

The problem of cheap transportation for immense quantities of oil has been solved by a line of 500 miles of underground main pipes from the oil regions over the hills and mountains of Pennsylvania, across New Jersey, under the North River, Central Park, the streets of New York, and the East River to distributing reservoirs at the refineries of Long Island. A rapid current is secured by a potential set up by pumping stations arranged at intervals along the line, like telegraph repeaters. Of these there are 22, and as the pressure communicated by the initial pump is exhausted by the retardation of friction, the oil is taken up and sent on by the next, just as from a hydrant a volume of water is drawn by a fire engine, and projected with vastly increased

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mechanico-motive-force and accelerated velocity, on its way. It is safe to say that the mechanical pressures thus developed are as difficult to control as the electrical pressures which we describe as high electro-motive-force. At all events we find that the engineers resort to specially devised threads and couplings, as we do to high insulations.

In Spain where hydraulic engineering has been reduced to a science, it is not uncommon to lead water in large mains for mining and public uses from elevated natural fountains through special pipes or hose, miles in length and thousands of feet fall, to points where the tremendous energy of the hundreds of pounds pressure thus secured may be utilized.

In many cases reducing valves are introduced to check the pressure which would otherwise be ungovernable, and the discharge is made into reservoirs, from which low pressure distributing conductors radiate to points of consumption.

In locomotive engineering the necessity of condensing the greatest possible mechanical potential in the smallest possible space has developed special appliances, under the control of trained, watchful and responsible men, each unit acting for a limited period of time. Thus these unusual and special applications of excessive pressures have been rendered feasible and desirable for this particular work.

It is not reasonable however, to infer that we may apply the same ideas to the ordinary uses of domestic life. Certainly it would be extremely hazardous for a mining engineer to take into his residence a service from the hydraulic system with which he tears away the side of a mountain.

In like manner it would be unreasonable and hazardous to depend upon a locomotive pressure for the operation of a steam-heating boiler which must be left to a great extent in the hands of domestics and others who have no conception of its mischief-making ability.

We cover immense distances in railway transfer of property and individual presence by employing high potentials. Fast trains on conductors of iron rush us swiftly from city to city, but from the Union depot, the point of distribution, we take the slower speed, the lower potential of the elevated road, the horse car or the omnibus which scatters us from door to door.

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Thus in every system of motion and transit we recognize the same law in governing the energy we develop, high potentials for transference or transmission over distances where we can commit the apparatus to trained hands, dropping to low pressures for distribution where we must come into close contact with the energy with which we are served.

Hence the principle of the use of high electrical pressures is not absurd or inconsistent with correct conceptions of future progress. The idea underlying the transformer is the logical outcome of experience, but thus far we have no satisfactory application to general commercial uses excepting the electric motor, and it seems likely that this will prove the check valve for which we have been seeking in the transmission of large powers.

The standard by which any high potential work must be judged is the practical value of the insulation which we can command in controlling and keeping in check the pressures which we create.

In the paper on the Municipal System, read at Altoona, the study of the vital principles underlying the modern incandescent lamp showed a surprising insight on the part of Mr. Edison, as illustrated by his original conception, embodied in a type which has not been improved upon by anybody during nearly ten years of subsequent experiment. In like manner these underlying natural laws of electrical distribution at safe pressures are now seen to have been clearly and sharply defined to his searching scrutiny, as is made evident to us all in the distribution patent applied for in 1880 and issued since our last meeting.

Yet we are confronted in the business of electric lighting even to-day by statements of interested parties that perfect control has been established over electrical energy when sent out from the dynamo at high pressures, by which, sometimes merely by subdivision of current into several small units, at other times by a reduction of its pressure by some system of inductive action, the dangerous current of the dynamo is supposed to be reduced to harmless conditions at the lamps.

It is only two years since the leading exponents of the electric lighting interests of New England gathered around a visionary young electrician in Boston, as he described in glowing terms the entire safety of a system of incandescent lights actuated by a subdivision of the Brush arc light current with 3,000 to 5,000 volts. The authorities of cities and towns were asked to consider the granting of franchises for lights adapted particularly not only to offices and stores, but private dwellings.

The determined efforts and glaring misrepresentations of several companies thus prospecting to use high pressure in order to distribute electrical energy for domestic consumption have prompted very careful inquiry on the part of many capitalists and business men, as well as of those insurance officials whose risks are likely to be materially affected by the introduction of new or practically untried methods.

In some cities the results of this inquiry have been to absolutely bar out the placing of lamps depending for their light upon currents of high pressure from the control of inexperienced persons.

All these devices and appliances have as their end and aim simply and solely the saving of an outlay of money in the copper conductors. When once an expenditure is conceded sufficient to allow bringing the electrical pressure to a point within a safe limit in personal contact with the wires, our difficulties are practically solved, for by so doing we not only rob the electric system, backed by the powerful steam-engine or the water wheel, of the ability to do personal injury, but we bring it within the limitations of cheap installation, so that the energy applied to the conductors can be distributed with small loss in spite of adverse conditions which are set up by those elements tending to promote leakage, and thus deprive us of the benefit of useful work of the current already created.

The problem as thus stated is not essentially different from that for controlling gas in systems of distribution for illuminating purposes. In gas we find direct and considerable leakage at pipe joints; a more obscure but serious escape through the pores of the metal; and friction on the pipe and upon the particles of the flowing gas itself, retarding its motion.

As an offset to this we have electrical leakage at points of suspension or support, also that peculiar expenditure of energy through and independent of the insulation, upon surrounding substances, which we call induction, and the waste in overcoming the resistance of the conductor which unites with that other form of friction, self-induction, to retard the flow of the current.

Though the causes of leakage may be diverse, yet the phenomena of the methods of escape, and particularly the resulting effect of the waste of energy, are thus closely analogous.

Thus every gas engineer will admit that it is rare that even at the low pressures made use of in ordinary business less than from 10 to 30 per cent. of the gas as measured by the meter at the works is lost before it can be registered in the meters of the consumers.

We are thus already able to do better than the gas people in electrical practice by far, and it is to the apparent ease with which cheap insulation is effected where conductors are aerially suspended that the visionary and uncertain ideas of many electric light managers seem to be due.

I venture the assertion that there are less than a dozen arc light superintendents in the United States to-day who can tell, from actual watchfulness of their systems, the percentage of energy which they lose in the resistance of conductors and in waste from actual leakage.

Two years ago there was no such thing as even a cheap ampere meter supplied by arc light companies as a part of the equipment of their stations. In March, 1886, the manager of a Florida station was unable to get such a meter, upon requisition to the company whose dynamo regulator had been tampered with.

To-day there is coming to be a realizing sense that high pressures do not absolutely enable us to disregard distances, and that lines of 15 and 20 miles, though supplied with a pressure of two or three thousand volts, really absorb a portion of the energy sent to the lamps. To-day all the systems of distributing boxes and other devices for running incandescent lamps upon arc light circuits are falling more and more into disrepute, while at the same time the public appreciation of the incandescent lamp as a proper unit of illumination is rapidly gaining ascendancy; and the transformer or converter (the latest modification of the idea of reduction and distribution from high pressures) is coming, among thoughtful men and careful insurance inspectors, to be considered in the same class with its predecessors. And we shall soon have well-defined regulations by which the standard of safety will be defined, not according to the difference of potential between the wire which enters our dwellings and the wire which departs, but by the total pressure exerted at the brushes of the dynamo by which the conductors which more directly serve us, are vitalized.

As long as the primary coil of the alternating system converter is properly and thoroughly insulated from the secondary it is safe and easy to manipulate the fixtures and lamps to which this secondary is connected. But these converters do not work without loss of energy, and this is particularly true when only a portion of their ultimate capacity is called for in actual labor performed.

A 50-light converter running its full load of lamps needs about four horse-power of electrical energy, and of this from five to ten per cent. is lost in the process of transformation with the most costly methods of construction.

The most careful experiments with new and specially constructed apparatus lead us to believe that not less than five per cent. is ever thus lost, and that ten to fifteen per cent. in commercial practice is a low estimate. This ten per cent., therefore, means about 300 Watts of electrical energy, or about 13,200 foot-pounds per minute of mechanical energy; or about two-fifths of a horse power.

We are obliged to dispose of this heat mainly by radiation. If the iron case of the converter be made tight, the radiation is slow, and the heat is concentrated largely in the coils. Hence it is only a matter of time when any known insulation will be affected, and gradually disintegrated. If the iron case is ventilated and currents of air are allowed circulation, condensation of moisture takes place and the tendency exists to break down the insulation between the primary and secondary wires, or between one or both of these wires and the earth.

When this breaking down occurs suddenly, the high pressure of the alternating current dynamo causes a tremendous expenditure of heat energy in an exceedingly short time; the insulation is set on fire, and frequently surrounding combustible material is charred or even ignited. In other cases an arc is established, the mass of copper in the converter is suddenly vaporized, and the tremendous expansive energy bursts the outside shell like a bomb.

This weakness, which applies to all forms of the converter yet devised, has led the insurance inspectors to prohibit their placement in buildings.

There is every evidence that the ultimate pressure of the dynamo, capable of almost instantly proving fatal to human life, may at any moment be brought to the lamp socket intended to be manipulated by a member of a family in a private residence. Any accidental connection with an earth contact, as for example a hand carelessly laid on a steam radiator, or even standing on moist ground while turning a lamp on or off, may form a path for the alternating current which is as shattering to the nervous system as a direct current of twice the pressure.

Even without this ground contact, if the person be thoroughly insulated, the body acts as a condenser and is alternately charged and discharged at the rate of about 250 times a second, more or less.

We should keep in mind always and everywhere, that the number of units of energy which we can transmit electrically or mechanically for any purpose whatever is always the product of two factors, the pressure and the current which results. We may therefore secure the same aggregate power by a large flow of current, and a lower pressure, or by a small flow of current actuated by an excessive E. M. F., and the hazard attending the small flow arises from the fact that when anything goes wrong, this same total energy seems practically to have a capacity for quicker and more vicious mischief, and expends itself to the destruction of our plans, and the disarrangement of our ideas and apparatus in what appears to be an infinitely short space of time. Hence it is obviously easier to protect ourselves against an expenditure of a certain number of units of energy in the form of electricity when actuated by a low pressure dynamo, by taking advantage of the ability of the current to create heat in a fusible safety link, an excessive flow opening the conductor and stopping the transmission.

We have also at all times a better control relative to leakage, and hence are more sure of keeping within our grasp the energy which we have thus provided ourselves with, perhaps at much expense.

This safeguard, in the form of a fusible conductor, is usefully applied in all our low pressure methods. In these the larger portion of the total energy developed is in units of current, and the small portion only is in the units of pressure. Hence, as the heating effect upon the safety catch varies as the square of the current, we can effect a nice regulation in the flow of energy, by grading carefully the melting points of safety fuses, by which we ensure an automatic control of the motive power.

Suppose, for example, it is desired to transmit a power equal to that required for 20 sixteen C. P. lamps. This is practically one and one-third horse power; it may be represented by 1,000 Watts of electric energy, and this, in turn, may be made up of 1,000 volts and one ampere, or by 100 volts and 10 amperes. If, with 1,000 volts and one ampere, a short circuit takes place in such a way as to double the flow of current, we have a heating effect equal to four times that of the original.

As the total volume of current at a maximum is but two amperes, it is difficult to standardize the safety fuse with sufficient exactness, so that it will safely carry one ampere and melt at two. This difficulty is one of the most perplexing met with in the early stages of the Municipal business.

A safety fuse which could be relied upon to carry a circuit taking three amperes of current, could not always be depended upon to melt instantly when the current rose to six amperes, in consequence of an accidental cross on the line. But although the energy expended in heating a fusible of a given length, at the moment of this rise, was represented by twice the previous pressure and twice the current, or four times the Watts, the life of the incandescent lamp carbons would decrease, not as the square, but as a much higher power of the current flow, and an instantaneous rupture of the carbons of several lamps, would very likely take place before the fusible wire would open the circuit.

Let this same energy be represented by 100 volts and ten amperes. A cross bringing about an equal percentage of change in the resistance of the circuit, and increasing the current from 10 to 20 amperes, might be counteracted in its

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effects upon the system, by the grading of fusible metals, between these limits of carrying capacity, so that the safety of the lamps would be practically absolute. In other words, it is vastly easier to make a safety catch, nominally carrying 10 amperes, which will melt with the increase of 50 per cent. in its load, than it is to make a safety catch carrying only one ampere which will melt with 100 per cent. increase.

It may be interesting before taking up the present status of our own Edison work, in operating incandescent lights by pressures higher than those used in the three-wire system, to notice what imitations and modifications of our methods have been made in a small way by other companies.

Dismissing, for the time, the Westinghouse system as applied to domestic lighting, we find that somewhat extended experiments have been made by them toward a method of distribution for streets.

Nothing can more clearly illustrate the expensive features and large losses attending the operation of converter plants, than the practical results laboriously reached by this system of street lighting, with the mistaken notion of carrying the converter principle into every department of an Illuminating Company's work. If we concede that any object is gained in the transformer system other than ready distribution of energy (for light alone, because we cannot secure power) over wide spaces, we must of course consider that it is to be found in the desirability of reducing the high pressure in order that we may handle it safely.

As there is no necessity of handling the lamps or attachments of a street system in such a way as to place ourselves in any danger when the current is on, it is perfectly plain that there is no necessity of the conversion of high to low pressure at or near the lamp. If no necessity of conversion, there is no compensation for the expense of the converter and the constant waste of energy it entails, nor is there any advantage in using for a given potential an alternating rather than a direct current. If we gain no advantage by the use of the alternating current, it is foolish to attempt to produce it with its specially hazardous effects upon human life, and the great expense entailed by the losses due to the inefficiency of the dynamo. If we have no special use for the alternating dynamo, with its necessarily high armature speed, we can certainly have no good reason for resorting to a steam wasting device like the Westinghouse engine.

Hence the companies who are now operating street lighting systems based upon this idea have not only builded on the wrong foundation, but of the most expensive and in large measure needless material. A very large percentage of the steam supplied by the boiler is wasted in consequence of the peculiar make-up of the engine itself. The power delivered to the belt of the dynamo is reduced by at least 30 per cent. in its transformation to electrical energy.

As the pressure thus placed at our service in the systems now in operation is only 1000 volts as compared with the 1200 which the Edison Municipal system utilizes, and the ratio of copper employed is inversely as the squares of these pressures (as 144 to 100), thus enabling us to effect a saving of nearly 33 per cent. in the size of Edison wires; and as a loss of probably 15 to 20 per cent. is unavoidable in the use of single light converters (one on each pole) with no apparent object except to create a low pressure in about six feet of wire (connected with the lamp) which is never touched by anybody, it is evident that including the engine, our Municipal systems are making a saving as contrasted with those of Westinghouse of from 40 to 50 per cent. Yet it is of no use to talk with those unfortunate capitalists who have been filled up at the factory of the Westinghouse Company regarding the superior advantages of this single light converter system. It is possible that some of them may realize that where they are called upon, as in one case lately noted, to develop some 200 H. P. of steam to run about 700–25 c. p. lamps, there is a leak somewhere, and that in all probability that leak takes place at all points along the line, from the throttle valve to the lamp carbon.

It is not necessary in addition to this to speak particularly of the fact that single light converters must cost somewhere from six to ten dollars per lamp, that the leakage in them and over the connecting wires as placed is so great as to enable people to take shocks when standing on the ground through dry poles, and that they occasionally take fire and char the wood in their vicinity. The conductors of 1,000 volts are bridged by a series of about twenty of these individual converters, the exact number in each bridge being determined by the amperes required by the candle power of the lamp, and no arrangement has been made thus far for the cutting out of the coils of such converters as may be temporarily useless in consequence of the burning out of a single lamp. No flexibility is here attained in the distribution of different powers, as all the lamps on each series must be the same.

Only a few of these systems have as yet been placed. The first one was at Staten Island, and a contract was made by the local company to place 1,000 lights in an adjoining town, but the original system was apparently too expensive and the second contract was allowed to go by default. There is no single advantage which can be claimed for this method over our own street system, while in a Westinghouse plant of 900-20 candle lamps, the converters alone will cost as much as the copper for an entire Edison system of lines to distribute the same light, each Edison circuit being five miles long with only five per cent. loss in the conductors. Or to illustrate still more forcibly, the converters for such a plant will cost about four times as much as Edison dynamos to do the same work, when purchased by a Central Station.

Very few examples of the United States Company's imitation of our street system are to be found in this country.

Regarding the one placed some months ago in Portland, Oregon, it will be of interest to note an extract from a report of our agent in Seattle, Mr. Mitchell, as to the electrical features, and the results which the system has there developed :

" The Portland plan is a regular two-wire system, operating " five 16 c. p. lamps in a series at $2.25 per month. They " burn practically free sawdust at a mill about two miles " from the principal lighting, and furnish interior lights from " the same wires.

" The street service is simply miserable; the hood, an " inverted cone, being placed 9 or 10 feet above the ground."

In this connection it is interesting to note a modification of the three-wire system, placed by Mr. Mitchell with Edison apparatus in Boise City, Idaho. Two Edison 600 volt, 26 ampere dynamos furnish current for several hundred lights, five 110 volt lamps being used in series on either side.

The dynamos run without spark and with dark smooth commutators. No sand-paper is used, and there is no more external evidence of the high pressure secured either in the case of these or the 1200 volt Municipal machines, than with the regular 125 volt dynamos. The system is supplied by one feeder, a mile and a half long, the positive and negative conductors (calculated for 300 16-candle lamps), being No. 6 B. W. G., equal to No. 40 Edison Gauge, and the Neutral No. 10, equal to No. 15 Edison Gauge. Pressure wires lead back to the centre of distribution. Each group of 5 lamps is supplied with a Municipal glass pencil fusible cutout and a switch. The company receives for each 16-candle power lamp until 10 o'clock seven nights in a week (stores all open Sunday evenings) $1.75 per month. All-night lamps, $3.00. There is probably no Edison plant in the country which has operated more perfectly since its starting on the 3d of July last than this high potential three-wire system, the only one of its kind.

Of course, under these circumstances, the lighting of a small room or store amounts to either a feast or famine, a series of lamps being turned on or off together, and the pressure is somewhat below the point where the lamp, when the carbon is broken, might possibly maintain an arc at the point of rupture, necessitating special safeguards, as in a Municipal series, to prevent the destruction of the lamp and the socket.

From a letter dated Boise City, Dec. 24 last, the following is extracted :

" Our light is entirely satisfactory and approaches our " most extravagant interpretation of success. It is pro- " nounced the best in the land by parties from the East. " We have now 310 lights aggregating 4,200 candle power. " Wish you would give me a rough estimate of expense of " another dynamo same as we have."

We are, of course, equipped far more thoroughly than are the United States people to do business on this plan, and for very sparsely settled districts at considerable distance from the source of power, this scheme may in some cases be desirable, particularly as for street lighting a series of Municipal lamps can be taken from the outside wires, amounting practically to a regular Municipal circuit, and

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with the same cut-out appliances and safety devices which belong to the 1200 volt dynamo.

The Thomson-Houston Co., with their usual facility for imitating everything which seems to them desirable, have arranged to operate in connection with their converter plant at Newton, Mass., a circuit of 40 sixteen candle power, 25 volt lamps, from the alternating current dynamo, but without converters, thus demonstrating their good sense in avoiding a portion of the large expenditure both in plant and in power required and incurred by the Westinghouse street system.

These lamps are operated as nearly as possible, even to the simplest detail, in imitation of the original Municipal methods as placed in Portland, Lockport and Denver. They have even copied the standard of volts and the form of cut-out.

The fact that they have not duplicated this plant would seem, however, to indicate that they have found some difficulties in operation in which perhaps they have not succeeded in obtaining the results of the Edison Company's experiments.

For the past ten years Charles Heisler, of St. Louis, has been with commendable pertinacity endeavoring to develope some practical notion in electric lighting. While the arc light was still young, he advertised with great flourish of trumpets, that he had succeeded perfectly in subdividing the arc unit of 2,000 c. p. so as to get any power which might be required with substantially no loss in economy. Like many other of the booming pretensions in the electric light field, this has never been put in practice, and after some years he was obliged to abandon this particular line of experiment.

Latterly the company formed to exploit his inventions (which has recently made extraordinary efforts to unload its patent rights and business) has undertaken to imitate the Edison Municipal. Of course, in order to cover distance, it was necessary to copy us in using a large number of low volt lamps in series. In addition to this, Heisler has proposed to "go us one better" by arranging an automatic control of the current on each individual circuit. The Bernstein 5-ampère lamp, about 15 volts for 25 candles, which is superior to anything which Mr. Heisler has been able to devise, was adopted to fill the gap necessary in order to bring out anything which might be sold as a completed system.

There are no two Heisler plants built on exactly the same general principle now in operation in the country, so far as late advices describe, but the type which appears to have been a favorite is that of the alternating dynamo, giving ten amperes on two circuits, each of these circuits being arranged with a huge resistance box automatically controlled, so that if the individual lamps are turned out at the sockets, equivalent resistance is introduced at the station.

It is proper to say in this connection, that in the event of an equal reduction of both circuits, a sort of automatic mechanism is called into action which cuts down the E. M. F. of the dynamo. This method introduces these complications in order to provide for the separate control of each lamp by the consumer. To guard against the distrust, hesitation and perhaps fear which would naturally be excited if a knowledge of the actual conditions were known to the purchaser and to the individuals who have occasion to use the light as furnished from central stations, specific professions are made by the officers of the company that the dynamo and its current are perfectly harmless.

A gentleman interested in electric lighting wrote, among other inquiries to the Heisler Company, the following:

" What is the total pressure of your dynamo ?

" What does the Vincennes (Ind.) manager mean when he " says 'The current in the brushes is 45 volts ?' "

The Engineering Department has on file the answer to these and other queries, signed by the Heisler Electric Light Company, A. Grauer, Sec'y, in which the following replies are given :

" When the Vincennes man says that the current in the " brushes is 45 volts, he simply states a fact. * * * We " have not left a chance for anybody to get a serious shock " from this system. We use the ordinary fire-proof wire in- " side the buildings. We have supplied about 650 lights to " stores and houses with the best results for the last two " years. * * * In the circuit of No. 8, B. W. G., if the " circuit were ten miles out and back, one-sixteenth of the " current of the 320 light machine would be used."

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Now, if this means anything, it is intended to carry the idea that by this phenomenal method the twenty ohms which represents the resistance of ten miles of No. 8 wire, is one-sixteenth of the resistance of a circuit of five ampere lamps, and it follows that the pressure must be 1,600 volts.

The peculiar statement about a current of 45 volts in the brushes is a curiosity in electrical literature but is easily explained when we consider that the alternating armature requires no brushes, and that the Heisler self-exciting machine has a commutator only for the gathering of a low pressure current for vitalizing its own field magnets. Thus, it is true that between the brushes there exists only a difference of pressure of 45 volts, while between the leading wires which supply the lamps, there is usually from 1,500 to 2,000 volts of alternating polarity which the unsuspecting consumer is thus likely to manipulate without realizing his peril.

Nothing more compromising, and possibly more disastrous to the reputation of electric lighting can be imagined, than this deliberate misrepresentation on the part of those who are making and selling this apparatus.

The socket contains a complicated shunt mechanism, involving a mechanical action which, in the early history of the Municipal system we found apt to become clogged by dust or impeded in its normal motion by any one of various causes.

The effect of its failure to operate, means the destruction of the lamp by a possible arc when the carbon breaks, accompanied with a liberal display of fireworks and possibly the scattering of melted metal and the igniting of combustible material before the arc can be arrested. This action occasionally takes place in these lamps, as is evidenced by the illustration of the rupturing of the bulb of a Bernstein lamp in the "Electrical World" of a week ago.

An interesting question arises in connection with these various attempts to economize copper by the use of high potentials. It seems likely in view of the recent utterances of eminent scientific men, that 500 to 600 volts should be regarded as the limit of safe pressure to be introduced into dwellings for ordinary domestic purposes. This pressure may possibly shock somewhat severely, but cannot kill.

As the minds of insurance experts are being called to debate this point, it is apparent that in discriminating between rules for incandescent light fitting, and for arc light apparatus, a limit will be definitely and carefully indicated as referring to the pressure developed at the dynamo, with the distinct understanding that no system has yet been devised, or is likely to be brought out hereafter, which can practically guard against an occasional and always unexpected manifestation of the full dynamo pressure at any point on the circuit or within its influence.

The progress of our own high pressure system since the report made at the Altóona Convention, if not very rapid during the recent frozen months, has been uniformly gratifying.

The first station started after the last session of the convention was Attica, Ind., with a capacity in dynamo equal to 300 20 C. P. lamps of the new Municipal type. Of these lamps we shall get 12, or a total of 240 candles, to the electrical H. P. This system has run without difficulties worth mentioning, from the date of starting, and the following statement is made by the secretary :

" Our plant is moving along satisfactorily to ourselves " and the general public, and we predict great success for " this branch."

The Illuminating Company of Rochester, N. Y., constructed during the fall months a large system of poles and wires, and on December 2 connected the last lamp of their original contract of 700 lights. Almost immediately they received an order from the city for one hundred and thirty-four additional, and have been operating them since January 1. The rate is $18.25 per year for a 20 candle lamp operated every night and all night, and the gross income is therefore about $15,225. From the first the light has been popular with the citizens of the wards lighted. About a month ago the auditing committee refused to approve the bills of the electric light companies until they had received evidence by photometric tests that the Edison lamps were giving 20 candles and the arcs 2,000 candles. The Edison Company satisfied them completely and raised the embargo. Whether the arc people have been equally successful doth not yet appear. Secretary H. L. Brewster writes under date of January 31 :

" We have no suggestions to make as to the Municipal, as " so far our experience is very satisfactory, and we are very " much pleased with its workings."

The Illuminating Company of Brockton, Mass., started on the 1st of October, 1887, a system of 350 street lamps of 15, 20 and 30 candles. As soon as the lights were seen another hundred of them were ordered by the city.

A letter from the manager dated January 3, says :

" The last of the additional street lights were connected to-day, and we now have 468 Municipal lights in successful operation. They give good satisfaction all round, and have the endorsement of the city government. The Municipal apparatus is all working very nicely. The dynamo is perfection itself."

The satisfaction which the city has derived from their use is tersely expressed in a telegram recently sent by the Mayor in response to an inquiry as follows :

" BROCKTON, NOV. 12, '87.

" WALTER WHITE, President Common Council, York, Pa. :

" The Edison Municipal lamps of fifteen, twenty and thirty candle power are given entire satisfaction on our streets."

" (Signed) J. J. WHIPPLE, Mayor."

The gross receipts from these 468 lamps amount to about $7,300, or about $16 per year, for a 16 candle lamp from dark until 12:30 o'clock.

A 200 light plant is now in process of erection in Tokyo, Japan, under the watchcare of Mr. Brenner, formerly of the Cincinnati Company.

Another 200 light plant has been placed in Vancouver, B. C., at a distance of four miles from the central station, the outgoing and return wires thus making a circuit of 8 miles.

The flexibility of this system is illustrated by the fact that the Denver Co. have for two years operated several circuits from a Brush arc light dynamo. The only necessity in a case of this kind is that the automatic regulator, if there be one, shall be removed so that with the constant load the machine will always develope a constant current, and that with a sudden variation of the load the potential shall drop, rather than rise and thus damage the remaining lamps.

Such a system as this was also run from an American arc light dynamo, in Saratoga, N. Y., for about a year without difficulty. The factory of Aultman, Miller & Co., Akron, Ohio, is to be lighted at once by about 200 Municipal lamps, replacing 20 arc lamps and operated from the arc dynamo.

The Denver Company recently found that on account of the greater efficiency of the Edison machine and the ease with which they could economically vary its circuit-carrying capacity, there was sufficient advantage to them to reject the arc light machine which had been specially constructed for the purpose by the Brush Company, and ordered a third Municipal dynamo which has now been furnished.

In some places we have encountered an urgent demand for a few arc lamps in the central streets of towns desiring a Municipal system for nine-tenths of their territory. This call has been met at Pendleton, Oregon, by joining the return wires of two 4-ampere circuits after expending 700 volts in incandescents, and carrying about 8 arcs on the united line, which thus provides about 8 amperes. The Pendleton system has four circuits in all, and of these two, with their load of Municipal and arc lamps, are cut off at midnight, and the other two, similarly divided, are run until morning. Experiments are now in progress as to the limits within which arc lamps can thus be operated in conjunction with Municipal circuits, and the results will be of interest to those present at the next session of this convention.

On Monday a Pieper lamp, of which a few samples were recently imported for test, was operated in the Laboratory with a current of only 2.7 to 3 Amperes, showing that they can probably be used to advantage on single Municipal circuits.

The application to streets, while affording an ample field for our efforts for all time to come, should not be regarded as universal. It is significant that the gas companies have been first to realize that we can by this means extend their field of profitable investment, because they can by overhead lines and electricity control higher pressures and consequently send energy to greater distances, than they can by underground pipes and gas. It is not impossible to cover the lighting of large cities by underground conductors; it is simply difficult to see how this can be effected commercially when gas companies have never found city lighting profitable where any special pipe system was required exclusively for this purpose. In all this work we start out with one of the essentials of regulation, a constant load and consequently a constant loss, and this loss can be predetermined with considerable accuracy.

Where systems of 2,000 lights or less are desired, we have every assurance of perfect success in every instance, even where the territory is large. In the Brockton and Rochester plants the circuits each contain from 5 to 12 miles of wire, and even where the loss is but 5 per cent. on a 10 mile circuit, the copper need not be larger than an arc light line, but as pointed out in a previous paper, this question of loss depends largely on the cost of a horse-power of electrical energy applied to the system.

Almost every station has within a few miles some suburb or village which can profitably be reached, and wherever a good price per lamp is offered, no instance of this kind within 6 to 8 miles should be allowed to pass without investigation. Special arrangement of conductors will of course be necessary.

The competition of the agents of arc light manufacturing companies for the business of new territory has brought about an exceedingly unhealthy state of things in street lighting. The time was when cities paid 80 cents and $1.00 a night per lamp. Of course the cost of building and operating arc stations has been greatly reduced in almost every detail, but not in any such proportion as from $365 to $60 per year. A fair price for all-night lighting is about 40 to 50 cents, and where coal and labor is cheap 35 cents may be profitable, but the actual cost to an Edison station where coal is worth $3 to $4, and a large proportion of the fixed charges are already provided for by the three-wire business, is rarely much less than 25 cents, or $90 per year, and it is evident that the manager who takes a contract at 20 cents, 18 cents or 16 cents, is either having his fuel contributed by some philanthropist, or has discovered how to get carbons without paying much of anything for them, or intends to hire convict labor, or all combined. Quite likely he has also forgotton that when he was interested in that young telephone exchange about 1880, he hung No. 16 iron wires on porcelain knobs and used an old Western Union switchboard for the exchange, connected subscribers at $2 a month, and paid 10% dividends to the stockholders without a thought that the life of the best iron overhead lines rarely exceeds ten years, and that the natural progress of events would oblige him to use a faster board in half that time. In other words, depreciation asserted itself, and in two or three years it seemed as if, like the Deacon's One-Hoss Shay, the thing " went to pieces all at once."

So it will be with much of the arc light business of to-day. Meantime, cities which have paid 40 cents for light, where the cost of lines is great, labor is high, coal is dear, and rents and insurance are serious, are hearing that country towns (where everything is cheaper) are getting their lighting for 25 cents, and are passing resolutions that they will either have as low rates as other people or build their own systems. Some of our Edison managers have already been trapped by this kind of competition, and are probably in a position where the more business they secure of this kind, the worse result their balance sheet will show at the end of the year. The precedent thus established is counteracted by future efforts only with difficulty, for it is never easy to raise the price of any public or private necessity. There is generally a question on the part of the municipality whether an arc or incandescent system is cheapest. With arc lights at ridiculously and unprofitably low figures, there is less opportunity for a healthy incandescent growth.

It is not to be expected, however, that this state of things can long exist, and a healthy readjustment of values in the arc field, will be the signal for a more general adoption of a comprehensive system of small lamps at low prices. Such a system we can supply.

An important feature of flexibility in this system is the ease with which we can secure any required lamp life.

It has been carefully calculated that the greatest economy is reached when the lamp renewals amount to 16% of the total running expenses of a station. In the three-wire system the company incurs no expense of this kind, outside of the cost of the lamps, for the customer performs the labor of noting their extinction and replacing them. In the Municipal, on the contrary, special patrol service is required, and in some cases rebate is claimed by the city for interruptions. These must be added to the lamp renewal account, and hence the intelligent manager, who pays only $1.00 per ton for coal, says with emphasis: "I am satisfied with a " low efficiency lamp if it has long life. My average has " been 3,000 hours, and I don't wish to change." The terms "efficiency" and "economy" are relative only. A low efficiency lamp is simply one which will, when run at the incandescence for which it is made, or at which it is guaranteed to live, say 600 hours, give a small amount of light for each watt of energy expended. A high efficiency lamp is, in like manner, one which gives a large candle power per watt, and survives the strain upon its carbon. Any lamp may, therefore, be run at any efficiency below its breaking point, by varying the pressure and consequently the flow of current.

It is of course impracticable to make and keep in stock several types of lamps of different degrees of economy, and so we may arrange, knowing the conditions of a given station, to lay out its lighting so that any desired life can be expected. The new Municipal lamps giving nominally a candle for every three watts expended, can be expected to last on the average 800 hours. A single movement of the dynamo regulator will change the entire economy of hundreds of lamps. Suppose the normal pressure of the machine to be 1,200 volts. Let it drop to 1,165 volts, and the light of a 30-candle lamp falls to 25 candles (16⅔%) the total watts expended drop about 6¼%, the energy for each candle of light rises about 12%, and the life increases from 800 hours to 1,580 hours (about 100%). Another turn of the regulator and the pressure stands at 1,125 volts, the candle power falls to 20 (33⅓% below its starting point), the total energy has fallen 13%, the energy for each candle of light has risen about 30%, and the life has lengthened to 3,700 hours, an increase of about 850%.

In the same way we can run these lamps high, an increase of 33% in light, from 30 to 40 candles, taking 13% more power, and reducing the life from 800 to 280 hours.

The manager who buys the cheap coal can therefore well afford to buy 30 candle lamps and run them at 25 candles, paying the extra 12% for coal and getting twice the lamp life and less patrol work, and this arrangement, though possibly not specially profitable to the Lamp Company, will at least give them the gratification of knowing that the aforesaid Municipal Manager has no fault to find. The color of the light in these high efficiency lamps is not perceptibly affected by this treatment within these limits.

It is proper to say in this connection, something about the use of the Municipal lamp for interior lighting. It is evident that in a series system the danger lies in any breaking of the continuity of the circuit. If this occurs in the open air by the mechanical overstraining of the line wire, by a poor joint, by corrosion or even by a failure of the cutout apparatus to work when the carbon gives out, no harm need be done beyond the temporary interruption caused by the extinguishment of all the lamps on one circuit. While it is desirable that the greatest number of lights consistent with reliability to the general system, shall be run on one wire, it is also vital that the total pressure of the dynamo shall not be forced above the point of safety to life, and of a comparatively easy suppression of an accidental arc. If the circuit opens while the current is on, the ampere meter in the station instantly records the fact, and an automatic alarm bell rings; the attendant immediately disconnects the disabled circuit entirely from the dynamo, and thus any tendency to mischief developed by a wire lying in the street is avoided as quickly as possible, and until the fault can be located and remedied. A cross causing a short-circuit, instantly fuses the safety wires and opens the line. If the cutout or even the hood, should by any possibility be entirely disabled, nothing can be injured outside the apparatus itself. Where the lamps are carried into interiors, all these possibilities are changed. The conductors being supported at regular intervals and subject to no mechanical strain or tension, an accidental break caused by a fracture in the wire, a cross, bad contact or other causes, will give rise to an arc which is not likely to be suppressed by a separation of the

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points. In such plants as have been installed for interior lighting, the greatest care has been used to provide proper ceiling cutouts, and substantial wires going from lamp to lamp, connected in such a way as to be mechanically secure. These cutouts are so arranged as to admit of ready attachment of special flexible cord, or conductors with fire-proof covering. Lamps should, in order to be most secure, be supported on rigid metal fixtures, not in any manner connected (even by insulating joints) with the gas system or other grounds. The sockets, which also contain the same cutout as the street lanterns, are made entirely of porcelain, the only metal being the working portions making contact with the lamp and serving as attachments for the fixture, and the bushing by which they are screwed to the fixture itself. No portion of these metallic parts is exposed to ready contact with the hands.

It is therefore unnecessary in the single operation which the customer is authorized to undertake, viz.; the changing of the old lamp for a new one, to touch any conducting material, and in no system which has thus far been installed has the control of the individual lamp by a key-socket been made possible.

The rules specify that entire circuits shall be disconnected from the station, and in some cases where the contract system can be applied it is thus possible to secure the lighting of stores, railroad stations, warehouses, and probably a few other classes of interiors, with the same satisfaction as in the case of streets, bridges, railroad yards, tunnels and mines.

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1889.

The Measuring and Indicating Instruments

used in the

Edison System of Lighting,

made by

Edison Lamp Co.

HARRISON,

NEW JERSEY, U. S. A.

BURGOYNE QUICK PRINTING CO., COR. WALKER & CENTRE, N. Y.

INTRODUCTION.

THE manufacture and standardization of all pressure indicating and measuring apparatus used by the Edison Electric Light Co., and sold by them to their licensees, has been intrusted by the Edison Electric Light Co. to the Edison Lamp Co.

In the development and improvement of these instruments the Edison Lamp Co. have spent much time and money,,and the instruments now made by them, which are described in this pamphlet, will not suffer by comparison with any instruments now in use for the same purposes.

All measurements are made by comparing the quantity to be measured with some standard. Electricity being known only by the effects it produces, can only be measured by measuring some of these effects, and, in order to do this, some *known constant effect* must be produced, which can be readily compared with some *known constant standard.*

In the pressure indicators herein described the resistance of a carbon filament, when a current passes through it, is used as a measure of the current, and, consequently, of the pressure acting on it. The resistance of a carbon filament varies with the current passing through it. This resistance, for any given current, has a definite fixed value, which is, therefore, a reliable measure of the current.

The carbon filaments used in these indicators are made specially for the purpose, and only *perfect* ones are used. The current allowed to pass through them is never large enough to permanently change their structure, surface, or resistance, and a pressure indicator, once calibrated, remains a reliable measure of pressure for a very long time, although it is left always in circuit. The pressure indicator simply measures the resistance of the carbon filament, which, as above stated, is a direct measure of the pressure of the circuit.

By this method, instead of a measurement of pressure direct, which is difficult, a measurement of resistance, which is the simplest electrical measurement, is made.

The voltmeters herein described are portable pressure measuring instruments. The potentiometer, or opposition method of measurement, is employed in them. This is the most approved laboratory method of measuring pressures, and its accuracy is only limited by the accuracy of the standard batteries used.

Experiments, extending over several months, show that the batteries used in these instruments are reliable, within one per cent., during their natural life. These batteries last several months, and new ones may be obtained from us, and put in at any time.

Electrical measuring instruments are of two kinds:

First—Direct reading instruments, or those in which a pointer moves over a scale, and, by its position on the scale, when at rest, shows the value of the quantity being measured. The Tangent Galvanometer and an Ayrton & Perry voltmeter are examples of instruments of this class.

Second—Zero instruments, or those in which the value of the quantity being measured is shown by the arrangement of the essential parts of the instrument *when a galvanometer connected with the instrument shows no current.* Wheatstone's Bridge and the potentiometer are examples of instruments of this class. When great accuracy is required in standardizing instruments it is universally done by reference to zero instruments. A good laboratory now is provided with reliable standards of resistance and electromotive force ; current standards being derived from these. So, all electrical measurements refer back to standards of resistance and E. M. F. All measurements of resistance are made by means of a Wheatstone's Bridge, which is a zero instrument. The best standard of electro-motive force is a Latimer Clark cell. A Daniel cell, under known conditions, is also a good standard. The working potential galvanometers in laboratories are standardized by reference to a potentiometer in which one of the above-mentioned cells is used. A potentiometer is a zero instrument. Thus, all electrical measuring instruments are standardized by reference to zero instruments.

With instruments of the first class any quantity within the range of the instrument may be read without making any adjustment, by simply looking at the scale or dial and observing the position of the pointer. For laboratory work, or where called upon to measure large and small quantities, these instruments possess decided advantages. But, as the length of the scale represents the entire motion of the pointer for the range of values the instrument can measure, the motion of the pointer for a unit change in value must be small if its range be large, and on this account it is necessary to look closely at the dial to read these instruments.

With instruments of the second class much more time is required to measure a quantity, as the instrument has to be adjusted until the galvanometer shows no current; but, with a properly constructed galvanometer, a small change in the value of the quantity being measured will produce a large movement of the galvanometer pointer. By this method, quantities can be read very closely, and small changes readily seen. Instruments of this class are specially suitable for engine room indicators. For incandescent lighting it is necessary to maintain a constant pressure on the circuit. In any plant the pressure being fixed by the lamps used, it is necessary to keep it always at this point, and no other pressure concerns us in the least. The engineer should have a pressure indicator which enables him to see readily *from a distance* whether or not his pressure is right. A zero instrument enables him to do this; as, when the pressure is right, the pointer is at zero in the middle of the scale, and a change of one volt may deflect the pointer half an inch, or one inch, from zero if desirable; so, small changes may be easily seen from a distance and the pressure kept right. The pressure indicators used by the Edison Co. are all zero instruments, and can be adjusted for the pressure used in any plant. The marks on the scale in front of which the pointer swings, are three-fourths of an inch apart, and, to deflect the pointer one of these divisions, a change of three volts in the pressure on the line is required.

That the standardization of these instruments might be reliable and always the same, we have procured the very best standards and instruments of comparison that can be bought.

As standards of electro-motive force we use the Latimer Clark cell and the Daniel cell, both of which are very carefully prepared after the specifications of Lord Rayleigh, Sir William Thomson and Dr. Fleming, and which agree with one another very closely.

Our standards of resistance were made and standardized at the Cavendish Laboratory, and certificates signed by Mr. Glazebrook accompany them.

All comparisons with the standards and standardizations of working instruments are done by the most approved methods, and by men thoroughly competent to perform the work properly.

Our standard of resistance is the legal Ohm, as obtained from the Cavendish Laboratory. We use the value 1.435 as determined by Lord Rayleigh and Dr. Fleming as the E.M.F. of a Clark cell in legal volts at 15 degrees C.

THE EDISON PRESSURE INDICATOR.

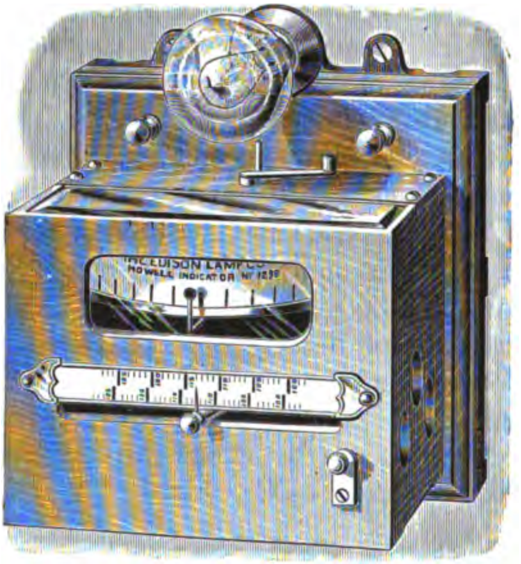

FIG. 1.—THE PRESSURE INDICATOR.

Patented March 30th, 1886, January 11, 1887.

With this instrument the pressure or electro-motive force of any circuit may be set at any desired point, and, when once set, it shows all variations in pressure, and indicates at any time whether the pressure is above or below the right point.

The principle upon which the action of the indicator depends is the variation in the resistance of a carbon filament due to the change of temperature, caused by the varying current passing through it. The circuit to be measured is made to act upon the carbon filament, sending a current through it. The amount of current which flows through the filament is determined by the pressure on the circuit, and varies with this pressure. The temperature of the filament varies with the current, so also does its resistance, the resistance of the filament being at any time a measure of the pressure acting upon it. The indicator is simply a

Wheatstone's bridge arrangement by which the resistance of the filament can be measured when a current is flowing through it. Although the indicator really measures the resistance of the carbon filament, the pressure (or volts) necessary to bring the carbon to that resistance, is marked on the scale; and with such a scale the indicator is a direct measure of the pressure of a circuit.

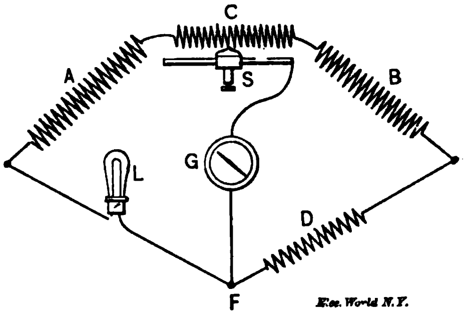

FIG. 2.

Fig. 2 is a diagram showing the essential parts of the Indicator. L is a high resistance lamp, giving the necessary high carbon resistance. D is a coil of wire, heavy enough to carry the lamp current without heating too much. These two resistances form one arm of the bridge, and the other arm is made up of three wire resistances, A, C and B. The galvanometer is connected between the point F and the frame upon which the sliding contact S slides; thus allowing the galvanometer contact to be made at any point of the resistance C. Let A plus the part of C on that side of the galvanometer contact be represented by A′, and B plus the part of C on that side of the contact be represented by B′; when the bridge is balanced and no current flows through G, $A'D=B'L$. G is a simple galvanometer, which shows the direction and relative amount of the current running through it. When the pointer is on zero no current is flowing in G, and a current one way or the other deflects the pointer to one or the other side of zero.

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Suppose the sliding contact to be in the centre of resistance C, and a suitable lamp to be in L, on sending a current through the indicator and gradually increasing it, the resistance of the filament becomes less and less, until, when the desired pressure is acting upon the indicator, A′D=B′L, no current flows in G, and the pointer remains on zero, with the galvanometer circuit either made or broken. This position of the sliding contact is marked to indicate what this pressure is, and, at any time, if the contact is at this point, and the pressure is adjusted until there is no current in G, the pressure acting on the indicator is the same as the pressure to which this point was adjusted. If, when the indicator is thus balanced, the pressure be increased, the pointer will move to one side of zero, while if it be decreased the pointer will move to the other side. If now the sliding contact be moved to some other point it will alter the value of A′ and B′, and it will be necessary to change the pressure until the resistance of L is changed enough to make A′D=B′L again. This position of S is marked corresponding with the pressure, and, in this way, the pressure that will balance our bridge with the contact S in any position on the coil C is found. Thus, the scale is marked in volts, and the pressure of a circuit can be set at any point that is on the scale of the indicator by moving the contact S to that point on the scale, and changing the pressure on the line until the bridge is balanced and the pointer remains at zero, with the galvanometer circuit either opened or closed. Two lamps are sent with each indicator, and two scales are marked, one for each lamp.

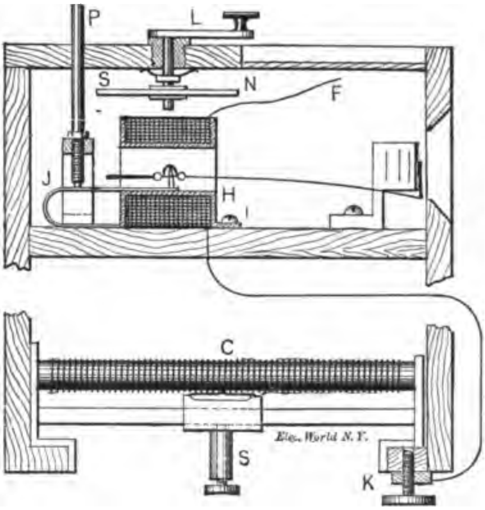

FIG. 3.—THE GALVANOMETER, SLIDING CONTACT AND RESISTANCE C.

Fig. 3 shows the galvanometer in section, also the resistance C and the sliding contact S which makes the galvanometer contact at any point of this resistance. The magnetic needle in the galvanometer consists of two pieces of steel wire, one on each side of the jewel centre. The steel point upon which the needle swings is fixed to a brass support H, which passes out the front of the galvanometer frame and is fastened to the base of the frame by a small screw; this allows the needle and its support to be taken out of the galvanometer at any time without interfering with any other part. By loosening the screw I the brass support H can be drawn out, bringing with it the steel point and magnetic needle and pointer complete. The spring J is normally in the position shown in the cut, being held down by the pin P. If the pin P be raised by unscrewing it, the spring J will rise and lift the needle off its steel supporting point and hold it against the frame of the galvanometer; this should be done whenever the indicator is carried about or handled, otherwise the steel point may become dull or broken. The directing magnet N S overcomes the earth's magnetism and makes a magnetic field for the galvanometer, by means of which the pointer may be brought to zero whatever the position of the indicator. The directing magnet may be moved one way or the other by the lever L. The galvanometer circuit runs from F (Figs. 2 and 3) through the galvanometer, through the switch to the metal frame on which the sliding contact travels and through the sliding contact to the point of contact on resistance C. The switch is a simple screw connecting the brass block K, to which the galvanometer wire is fastened, to the metal frame carrying the sliding contact; when the screw is withdrawn one or two turns so that it no longer touches the frame of slider the galvanometer circuit is broken. The upper part of the box which contains the galvanometer is separated by a wooden partition from the lower part which contains the resistances, the galvanometer and scale being fastened to this partition.

The lamp forming the high carbon resistance is screwed into a socket on the base of the indicator just above the box holding the galvanometer and resistances. Half of the top of this box is of glass, so the light from the lamp shines through the glass upon the back of the paper scale, in front of which swings the end of the hand or pointer of the galvanometer; and this paper scale being translucent, allows enough light to pass through it to render the pointer and scale clearly visible.

The resistances A, B and D are wound upon one wooden spool, which is placed in the lower part of the box under the partition; this space being ventilated through the sides, bottom, front and back of the box. The spool is also made so that the wire upon it is well ventilated.

The resistance C and frame carrying it and the sliding contact are also placed in the lower part of the box; the handle by which the sliding contact is moved projects out through a slot in the front of the box, so it can be readily moved. The resistance C is wound upon a carefully insulated brass rod; the sliding contact also slides along a brass rod. These two brass rods are connected rigidly by two brass pieces which are screwed to the box, and have lugs which fit in the ends of the slot in which the handle of the slider travels; these serve to maintain the proper distance between the two brass rods, so the contact spring is always in proper contact, and the lugs keep the parts in line with the slot so the handle never jams.

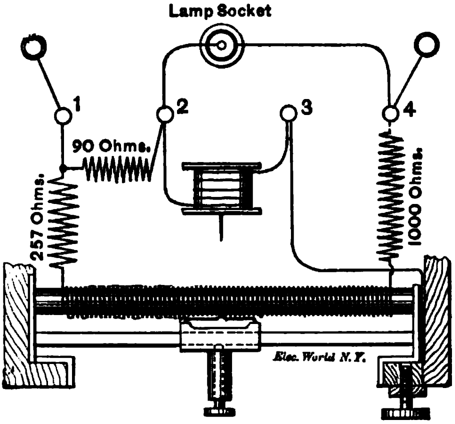

FIG. 4.

Fig. 4 shows the connections of the indicator as they exist in the instrument, the coils, however, being shown separately. The ends of the coils are each soldered to a washer and these washers are held together by screws. These connections, four in number, are shown in fig. 4 in the order in which they exist in the indicator. These connections are in the upper part of the box, back of the galvanometer, on the base or back of the indicator and can be readily reached when the cover is removed.

CORRECTION FOR TEMPERATURE.

The coils A, B and D are all wound on one wooden spool. When the indicator is balanced the product A D is equal to the product B L; A, B and D are wire resistances, and are enclosed in the box; L is an incandescent lamp in the open air above the box. When the indicator is left in circuit the coils A, B, D gradually heat up till they attain a constant temperature. The lamp L, however, attains its constant temperature immediately, and is practically independent of outside influences; consequently, as the indicator warms up, both factors in the product A D increase (the wire increasing in resistance as the temperature increases), while only one factor in the product B L increases. The product A D, therefore, becomes greater than the product B L, and the hotter the coils get the greater the difference between the products. To keep the products equal

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as the temperature changes, B must increase enough faster than A or D, so that for any increase in A and D, B increases enough to make B L still equal to A D. A and D are German silver wire. If B were also German silver wire the three coils would increase in the same ratio and A D would become greater than B L. If B were copper wire it would increase very much faster than A or D, and as the indicator warms up, B L would increase more rapidly than A D, so B L would become greater than A D.

If, however, B is made partly of German silver and partly of copper the parts can be so proportioned that, as the coils heat up, both products increase equally and the indicator remains balanced at any temperature.

IMPORTANCE OF RELIABLE INDICATORS IN ELECTRIC LIGHT PLANTS.

The indicator is used to show whether the pressure of a circuit is right, or high, or low. It is of the utmost importance in using incandescent lamps that the pressure on the circuit should be kept right. There is a strong natural tendency to run the lamps too high, as with most people the term "electric light" means a great quantity of light. Acting on this idea they run up the pressure on the circuit and make the lamps give much more light than they are intended to give. This causes the lamps to burn out much sooner than they otherwise would. The interests of the Edison Companies and of the parties operating plants demand that the lamps be burned at or about normal pressure. If the pressure on a circuit is gradually increased the lamps become brighter and brighter, but the change is so slow that it is not thought to be a great one, the light is satisfactory, and the idea that the pressure is too high and the lamps are giving too much light, does not suggest itself to the persons operating the plant; soon lamps begin to break and complaints come to the Lamp Co. that the lamps are poor. In many such cases the nature of the complaints give sure indications of high pressure, yet the persons operating the plant think the lamps are not giving too much light, and

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are perfectly sure the pressure is all right. It is of the utmost importance that each plant have an accurate, reliable indicator by means of which the pressure can be kept right. The accompanying table shows how rapidly the life of lamps becomes less as the pressure becomes greater. Thus, if a 107 volt lamp will burn 1,000 hours at 107 volts pressure, it will only last 500 hours at 110 volts pressure. In no better way can the necessity of good regulation be shown.

TABLE SHOWING LIVES OF LAMPS AT DIFFERENT E. M. F.

Volts acting on Lamp.	VOLT AT WHICH LAMP GIVES 16 CANDLES.																				
	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110
90	1000	1818	1782	2269	2965	3863	5020														
91	758	1000	1314	1722	2249	2981	3806	4984													
92	577	760	1000	1310	1712	2230	2893	3781	4852												
93	440	580	763	1000	1306	1702	2211	2865	3703	4773											
94	337	444	584	765	1000	1303	1692	2193	2834	3653	4696										
95	258	341	448	587	767	1000	1299	1683	2175	2804	3605	4623									
96	199	262	345	452	590	769	1000	1295	1674	2158	2774	3558	4552								
97		202	266	348	455	593	771	1000	1292	1665	2141	2746	3513	4483							
98			206	270	352	459	597	778	1000	1289	1657	2126	2718	3472	4417						
99				209	273	356	463	600	775	1000	1285	1648	2109	2693	3427	4355					
100					212	277	360	467	608	777	1000	1282	1640	2095	2665	3387	4293				
101						216	281	363	470	606	779	1000	1279	1632	2078	2640	3347	4232			
102							219	284	367	474	609	781	1000	1276	1624	2064	2616	3308	4176		
103								223	288	371	477	612	783	1000	1273	1618	2050	2592	3271	4120	
104									226	291	375	480	615	785	1000	1270	1610	2036	2578	3235	4064
105										230	295	378	484	618	787	1000	1267	1602	2022	2546	3199
106											233	298	382	488	621	789	1000	1264	1596	2009	2524
107												236	302	386	491	624	792	1000	1262	1589	1996
108													239	306	389	494	627	794	1000	1260	1582
109														242	309	393	497	629	796	1000	1258
110															246	313	396	500	632	798	1000

INDICATORS FOR ISOLATED PLANTS.

Indicators sent to isolated plants are adjusted and standardized to balance at the pressure required by the lamps used in that plant. Each indicator is provided with two lamps and the indicator is standardized with each lamp separately and the scale marked for each lamp. Thus, if 103 volt lamps are to be used in a plant, we mark two points on the scale, each point showing where the sliding contact must be placed to make the indicator balance with 103 volts acting on it when one of the lamps is in place—one point for each lamp. One of the lamps is numbered in red ink and one in black ink. The point on the scale to be used with the first lamp is also marked in red, and the point to be used with the second lamp is marked with black ink. If the sliding index be placed at either point and the lamp marked with the same color be in the indicator when it is balanced, the pressure at the indicator is 103 volts.

These points on the scale are marked like this $\overset{102}{|}\quad\overset{103}{|}\quad\overset{104}{|}$ showing the 103 mark as well as the distance and direction in which the index is moved to set the indicator one volt higher or lower than 103. If it is desirable to set the indicator at, say, 106, move the index in the direction shown by the 104 mark and three times as far from the 103 mark as the 104 mark is. In isolated plants, connect the indicator either to a lamp circuit where lamps are connected, and if possible to a circuit where lamps are burning most of the time, or to the centre of distribution if there is only one such centre. In the latter case it is necessary to set the indicator for a pressure as much higher than the voltage of the lamps as the loss is from the centre of distribution to the lamps. Thus, in the above-mentioned case, a 103 volt plant, if the loss from the centre of distribution to the lamps is three per cent. we must set the indicator for 106 instead of 103, as explained above.

INDICATORS FOR CENTRAL STATIONS.

Central stations, using comparative indicators, use three pressure indicators. Two of them are connected to the pressure wires from the end of the standard feeder, and one is used as a standardizing indicator to adjust the first two at any time. The two regular pressure indicators, being connected to pressure wires, cannot be standardized properly before sending out, as, when in use, the pressure wires are in circuit with them, and the pressure at the indicator is the pressure at feeder end *less the loss in the pressure wires*, and, as this loss is an unknown quantity, it cannot be allowed for until the indicators are connected and the loss measured. No scale is marked on these two indicators. The third or standardizing indicator sent to central stations has a scale marked on it, covering a range of about 15 volts. In using this indicator it is put in circuit in place of either one of the two regular pressure indicators, to tell whether these have changed in any way. To do this, bring the regular indicator to zero, then throw the standardizing indicator in its place and measure the pressure at the feeder end by the reading on the scale when the indicator is balanced. This reading should be the pressure at feeder end, less the loss on the pressure wires, which has been previously determined. Thus, to hold the feeder end at 108 volts, when the loss in the pressure wires is six volts, the standardizing indicator must balance at 102 on the scale. In this case, to standardize our two regular pressure indicators, adjust the pressure (by field resistance boxes) till both indicators are balanced, then throw the standardizing indicator in place of one of the regular indicators, and see whether or not it balances when the index is at 102 on the scale. If it does balance at 102, the regular indicator is all right; if not, make it balance at 102 by changing the dynamo-field resistance box, then throw the regular indicator in circuit again and make it balance by moving the sliding index. Repeat this two or three times, to be sure the pressure has not changed while standardizing. Now, standardize the other indicator in the same way. The standardizing indicator should only be used for that purpose. Do not use it for other purposes, or leave it in circuit when not using it. Standardize the two pressure indicators frequently—once in two weeks is not too often. One week run at high pressure may cost many broken lamps, but the time taken to standardize will cost nothing.

THE STANDARDIZING INDICATOR.

There are two methods of using the standardizing indicator :

First. The one previously mentioned, of throwing it in circuit in place of the indicator to be standardized. This is accomplished by the switch shown in cut.

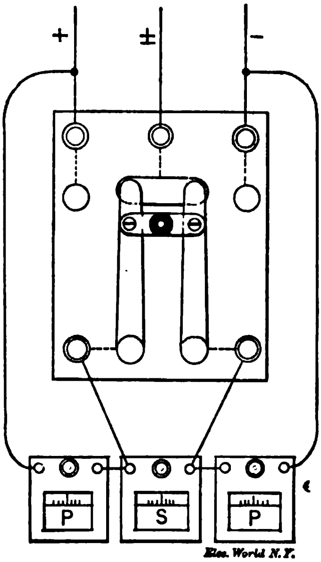

Fig. 18.

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It is connected as shown, + ± — being the pressure wires; P P the two pressure indicators, and S the standardizing indicator. When the arms of the switch are in the position shown in cut, the two pressure indicators are in circuit, but the standardizing indicator is not in circuit. Throwing the arms of the switch on either side, cuts one of the pressure indicators out of circuit, and throws the standardizing indicator in circuit in its place. When used in this way, the reading on the standardizing indicator should be less than the pressure to be maintained at feeder ends *by the amount of loss in the pressure wires.* If these pressure wires are of copper (about No. 12), this loss is neglectable and the standardizing indicator should balance at the feeder end pressure. If, however, the pressure wires are iron, the loss is often 4 to 10 volts, and must be allowed for. In this case the standardizing indicator should balance 4 to 10 volts lower than the feeder end pressure. This drop is determined by the voltmeter.

The second method of using the standardizing indicator is to connect it to the service supplying the station lamps.

When the load on the system is very small—on Sunday morning or on a bright day—the pressure is practically the same at all points on the same side of the system, so it is the same on the station service as it is at the feeder ends. If at such a time the standardizing indicator be connected to one side of the system on the station service, and the pressure there be made the same as is maintained at the feeder ends, the feeder end pressure is right and the pressure indicators may be adjusted to zero at that pressure. The only disadvantage in this method is that the indicators can only be standardized when the load is very light.

POINTS THAT DESERVE PARTICULAR ATTENTION IN USING AN INDICATOR.

THE EXTRA LAMP.—A lamp that has been tested and sent out with an indicator is not likely to change. Experience shows that they remain constant for a very long time; still, to correct any *possible* change in a lamp, an extra one is sent with each indicator. Two lamps are sent with each indicator, only one of which can be used at any one time, and points are marked on the scale for each lamp. An indicator standardized for 103 volts will balance with 103 volts acting on it, when the lamp marked with red is in use and the index is on the red mark on the scale, or with the lamp marked with black in use and the index on the black mark on the scale. It is intended that one lamp shall be used and the other lamp be kept as a check upon the one in use. A lamp that is used continuously may change its resistance and make its indications wrong. One that is not burned will not change, therefore, one that is not burned is kept to check the one that is burned, so at any time the indications of the first one can be corrected by reference to the second one. Suppose the red lamp to be burned continuously and the black lamp to be the reserve or check lamp. To check the readings of the red lamp by reference to the black one proceed as follows: When the current is steady and the hand or pointer remains on zero when the galvanometer switch is open or closed, open the galvanometer switch, change lamps (putting in the black one) and move the index to the black mark; now close the galvanometer switch and the pointer should remain on zero. If it does not remain on zero the two lamps do not agree, and a new mark must be made for the red lamp so they will agree. To do this, change the pressure on the line (by resistance box) until the pointer comes to zero, with the black lamp in and the index on the black mark; now change lamps again, and move the index till the pointer comes to zero with the red lamp in, mark this position of the index. Now repeat the operation, *adjusting the pressure of the line so the pointer is on zero when the extra lamp is in use and the index on the mark corresponding to this lamp, then setting the indicator by moving the index so it balances at this pressure when the first lamp is in use.*

The correct pressure is shown by the extra lamp; adjust the pressure by this lamp, then make the indicator balance with the first lamp in. One lamp is kept in use and the extra lamp, which is never burned, except long enough to check the first one, is kept as a check upon it. When an indicator is first put in use it should be checked about once in two weeks; if after a few weeks it is found not to have changed it need only be checked once a month.

THE GALVANOMETER.

The galvanometer shows at any time whether the indicator is or is not balanced; it is a monitor showing by the position of the pointer whether the pressure is right or wrong.

An indicator without a properly working galvanometer is useless, as it has no means of showing when it is balanced or when it is not. It is of the greatest importance that the galvanometer should be kept in good order, and that the person using it should know that it is in order.

When the indicator is balanced, the points F and C, to which it is connected, have the same potential; *then no current will flow through the galvanometer, and the pointer will remain in one position with the galvanometer circuit either open or closed.* It is then the duty of the galvanometer to show whether or not any current is flowing through it, and if there is, what its direction is. When the galvanometer circuit is open, the pointer is adjusted so it stands at the heavy mark on the center of the scale; when the circuit is closed, as long as no current is flowing through the galvanometer the pointer will remain in this position. A current in one direction will move the pointer one way, and a current in the other direction will move it the other way. A deflection of the pointer in one way shows too high a pressure, in the other way too low a pressure.

ADJUSTMENT OF THE GALVANOMETER.

It is necessary that the pointer should swing freely over two divisions of the scale on each side of the centre. It is adjusted to swing over two and one-half divisions on each side of the centre, and pins are placed in the box which stop the hand there and prevent the pointer or magnetic needle from going too far and sticking so that it cannot swing back. If the spring J (Fig. 3) is held down flat against the bottom of the galvanometer case by the pin P, and the indicator is leveled so the pointer does not touch the scale nor the magnetic needle touch the sides or bottom of the galvanometer case, the pointer will be free to swing over the scale as it should. If the pointer does not swing freely, first see that the spring J is out of the way of the magnetic needles and their support. Remove the cover and see that the point of the pin P projects through the hole in the spring J. If it does not, make it do so. See that the spring J is held flat on the bottom of the opening in the galvanometer case. If, on screwing down the spring J, the hand carrying the pointer and magnetic needles does not settle upon the needle point which supports it, but remains up against the top of the case, raise it a little by the pointer and it will settle in its place, so that it swings upon the needle point. Now level the indicator so that the pointer swings clear of the scale. The pointer should now swing freely along the scale. If it does not, hold a lamp so the light shines back of the galvanometer and look under the scale from the front and see if the magnetic needle touches the sides or bottom of the case. If it touches the bottom on one side, level the indicator so that it does not touch. If it touches the sides, move to the middle the metal piece H carrying the needle point, so that it no longer touches the sides. When this is all done the hand must swing freely. All this is done before the indicator is sent out. These directions are given to show how it can be done in case it becomes necessary at any time. When the pointer swings freely, open the switch (Fig. 3) by unscrewing it two or three turns, and by the lever L move the magnet N S till the pointer stands in front of the centre mark of the scale. This should be done every day; when the dynamo is running and the current is on, open the switch and see that the pointer is in the centre when the switch is open. Now close the switch and keep the pointer in the centre of the scale by regulating the pressure by the resistance box. It is very important that the lever L be kept so adjusted that the pointer stands in the middle of the scale when the switch is open, and it is important that this adjustment be made when the dynamo is running and the load is on.

THE SWITCH.

The switch is closed when the end of the screw touches the brass frame of the slider. It is only necessary to screw this down till it does touch. Screw it down firmly enough to make a contact, but do not force it down so hard that the block of brass is forced away from the wood. The switch carries an exceedingly small amount of current and it is only necessary to have a contact to answer every purpose. To open the switch it is only necessary to back the screw one or two turns, enough to be sure the end no longer touches the brass frame.

Whenever the extra lamp is used to check the one in use, or whenever the lamp is taken out for any reason, always open the switch before taking out the lamp.

Never unscrew the pin P far enough to get the point on its lower end out of the hole in the spring. As soon as you see the hand is raised so that the jewel does not rest on the needle point, stop unscrewing the pin P. It is only necessary to do this when the indicator is to be carried about or shipped.

Put the extra lamp away in a safe place, so that it can not be used for other purposes, or be broken.

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SETTING UP THE INDICATOR.—Fasten the indicator to the wall where it can be conveniently seen. Free the needle by screwing down the pin P on back of cover. Now, level the indicator with reference to the hand and pointer. The pointer must swing freely along the scale, even if the indicator is not exactly level. Connect the indicator to the circuit as directed, and put in the lamp numbered in red; put the sliding index at the red mark on the scale. The current is now flowing in the indicator and the lamp is lit up. Before closing the galvanometer switch, adjust the lever on top of indicator, so that the pointer stands at the heavy mark in centre of scale. Close galvanometer switch, and if the pointer is deflected one way or the other, *bring it back to the centre by regulating the pressure by means of the field-resistance box. Never touch the lever on top of indicator, except to bring the pointer to the centre when the galvanometer switch is open.* Keep the pointer on the centre of the scale by adjusting the field-resistance box. As long as this is done, and the indicator is kept in adjustment, as before directed, the pressure will be right.

In putting up the indicator, select a place ten or twelve feet from the dynamo, and at least eight feet from wires carrying the heavy dynamo currents.

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THE VOLTMETER.

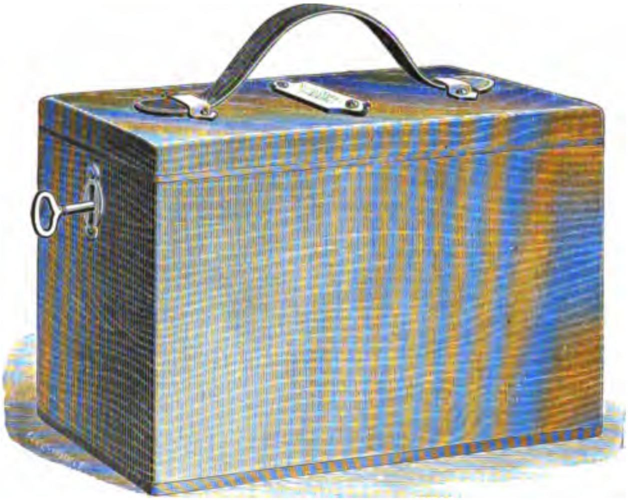


Fig. 5.

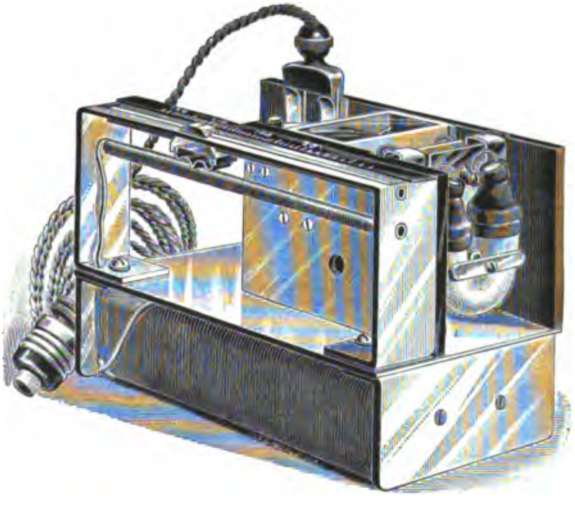
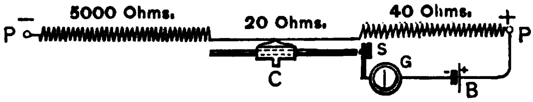


Fig. 6.

By means of the voltmeter the pressure at any point of a circuit may be measured.

The method employed in this instrument is known as the potentiometer or opposition method.

The voltmeter contains a small Daniell cell or a Clark cell of known constant E. M. F. The E. M. F. of this cell is opposed to the E. M. F. in a part of the voltmeter circuit. This part is varied by moving a sliding contact (to which one terminal of the battery is connected), along a resistance forming part of the voltmeter circuit. When the E.M.F. in this part of the voltmeter circuit, around which the battery is connected, is equal to the E.M.F. of the battery circuit to which it is opposed, no current will flow in the battery circuit, and the galvanometer, which is in this circuit, will show no deflection.



Elec. World N.Y.

Fig. 7.

Fig. 7 is a diagram of the instrument. P P′ are the terminals to which the circuit to be measured is connected. B is the battery of known E.M.F.; G, a galvanometer; C, a contact that is adjustable along the 20 ohms; S, a switch closing the circuit from P′ through the battery and galvanometer to the contact C. Consider the closed circuit from P′, through B G C, part of the 20 ohms and the 40 ohms, back to P′. Suppose the positive pole of the battery, and the positive pole of the circuit, to be measured, are both connected to P′ and a current flowing from P′ to P, then in this closed circuit two electro-motive forces exist, which tend to set up currents in opposite directions through B and G, the battery tends to make a current through G from left to right, and the E.M.F.

from P′ to C tends to make a current pass through G from right to left. When the E.M.F. from P′ to C is equal to the E.M.F. of the battery, no current will flow in G, as the two equal E.M.F.'s are opposed to each other and prevent a current flowing in the galvanometer circuit. Knowing the E.M.F. of the battery and the value of the resistances, it is only necessary to know the position of C along the 20 ohms to know the E.M.F., acting from P′ to P, which is the quantity to be measured. The voltmeter has two batteries which by simple connections may be arranged either in multiple or in series. When the batteries are in multiple, the pressure necessary to balance the instrument is read directly off the scale in volts. When the batteries are in series, the pressure required to balance the instrument is known by doubling the scale reading. The scale usually is marked from 90 to 130, unless otherwise ordered. With the batteries in series, pressures from 180 to 260 volts may be read.

When so ordered, the voltmeter is arranged to measure high resistances by the direct deflection method. A scale is marked on the galvanometer showing the deflection of the needle, and a simple formula gives the resistance of the insulation or other high resistance to be measured. The voltmeters are arranged to measure from 10,000 to 200,000 ohms, or from 1,000 to 200,000 as ordered. This makes a very convenient instrument for an inspector, as it enables him to measure the insulation of his lines as well as pressure.

THE POCKET VOLTMETER.

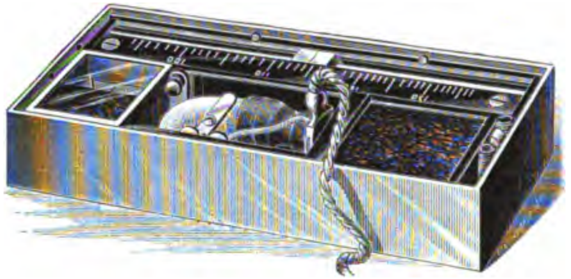
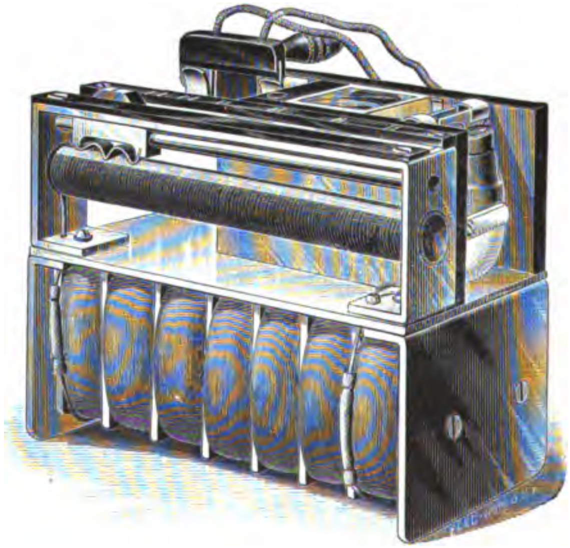


Fig. 8.

This is essentially the same as the voltmeter, except it has only one battery and has a metal case. It is 6½ x 3¼ x 1¼ inches, and can be readily carried in the hip pocket. This is a very convenient instrument for inspectors, but for central stations the regular voltmeter is preferable.

THE MUNICIPAL VOLTMETER.



No. 9.

This instrument is similar in principle to the regular voltmeter. It is made to read the pressure on municipal circuits which range from 800 to 1400 volts.

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AMPERE-METERS.

The winding of the voltmeter is changed on special orders to make the instrument read current in amperes. This makes a convenient instrument for measuring any lamp or current below six amperes or higher than this for special purposes.

THE BATTERY.

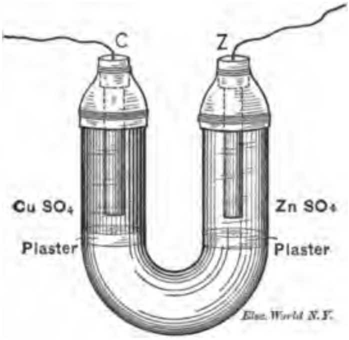

Fig. 10.

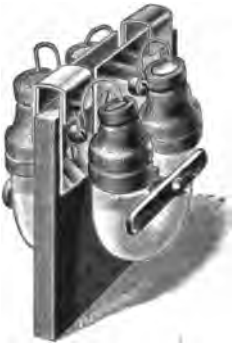

Fig. 11.

Battery, Patented Nov. 8, 1887.

Figs. 10 and 11 show the battery that is used with the voltmeter. It is what has long been desired, a portable air-tight Daniell cell, in which it is impossible for the copper sulphate to come in contact with the zinc electrode for three or four months, and during this time the slow progress of the copper sulphate towards the zinc electrode is plainly visible. The blue copper sulphate colors the white paste as it advances, marking clearly its progress. As soon as the blue reaches the end of the white paste, where it comes in contact with the zinc electrode, the battery may be thrown away and a new one put in. All the trouble of cleaning out and refilling batteries is thus done away with. The ends of the tube are closed with rubber tubes; one end of a rubber tube is stretched over the end of the glass tube and the other end encloses the electrode. The copper sulphate solution as it colors the white paste combines with it and the new compound occupies less space than the constituent substances, so an inward pressure is caused which helps to keep the cell tight.

New cells may be procured at any time from the Edison Lamp Co.

A special form of the Latimer Clark cell is also used in these voltmeters. These cells remain constant much longer than the Daniell cells, and in practice give very good results. The Clark cells, however, vary with temperature, changing one per cent. for each 25° Fahr. We have had these Clark cells in use for four months, and the results obtained from them are very satisfactory. If they continue giving such satisfaction for a sufficiently long time we will use them in all voltmeters.

USES FOR WHICH THE VOLTMETER IS INTENDED.

The principal use of the voltmeter is to determine the pressure *at the lamps* in different parts of the circuit. In central stations a constant pressure is maintained at the feeder ends; the voltmeter shows just what the pressure is at any point of the circuit. Points distant from feeder ends have a lower pressure than the feeder end pressure. The voltmeter shows just how much lower it is. In this way any low points that exist in our system can be found, and by applying local remedies, such as making a better balance between the two sides or strengthening the mains or services, the whole system can be brought to about the same pressure. An inspector of isolated plants by a voltmeter can adjust the pressure at any point he wishes, and prove or correct the readings of the indicator.

Another use for the voltmeter is to measure the loss in pressure wires carrying indicator currents in a central station.

By disconnecting the indicator and connecting the voltmeter to the pressure wires, the pressure at the feeder end can be measured direct. As the resistance of the voltmeter is 5,000 ohms there is no appreciable loss in the pressure wires when it is connected to them. With the voltmeter on the pressure wires the pressure at the feeder ends can be adjusted. Then, by connecting the indicator to the pressure wires, the new reading on the voltmeter can be taken, (which will be less than the first reading by the loss in the pressure wires caused by the indicator current). The sliding index on the indicator is moved till it balances with this pressure. The indicator can be checked at any time by connecting the voltmeter around the indicator and making the reading the same as it was when the indicator was set. Whenever the voltmeter is used to measure the pressure at the feeder end, by the pressure wires, *disconnect both indicators belonging to that feeder.* If, when the pressure on one side is measured the indicator on the other side is left in circuit, the current for this indicator flowing in the neutral pressure wire will cause an error in the readings due to the loss in this neutral pressure wire caused by the indicator current flowing in it. A voltmeter left in circuit at any point in the system, and observed every few minutes, will show by the amount of the variations in its readings how carefully the regulation is performed in the station. Any station not getting good life from its lamps should measure the pressure *at the lamps* when the evening load is on, and again when the load is light. These measurements will frequently show the causes of lamp breakage, and will suggest the remedy.

THE COMPARATIVE INDICATOR.

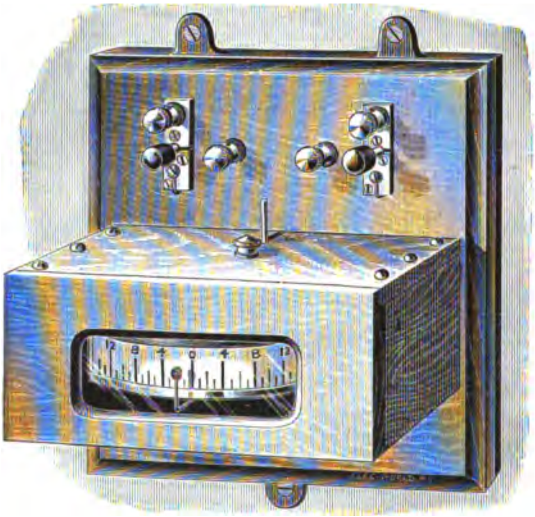

Fig. 12.

(Comparative Indicator, Method Patented Nov. 16, 1886.)

In distributing systems it is necessary to maintain the same pressure at the ends of all the feeders. This may be accomplished by connecting a pressure indicator to each side of each feeder end and regulating each point by reference to these pressure indicators. This method in a three-wire system requires twice as many pressure indicators as there are feeders, each one of which has to be kept in adjustment. The same result may be accomplished by maintaining the desired pressure at the end of one feeder by reference to pressure indicators, and at the other feeder ends by reference to comparative indicators. The advantage of this method is that the two pressure indicators only need to be kept in adjustment, the comparative indicators being once set up requiring practically no attention.

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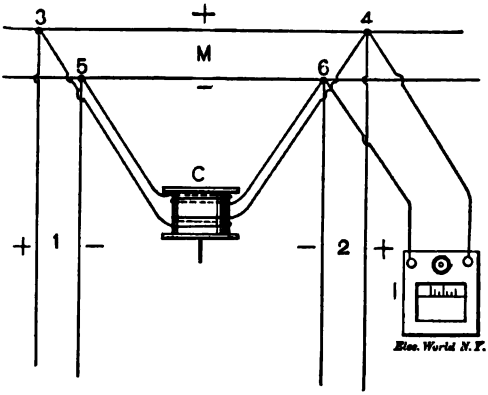


Fig. 13.

Fig. 13 is a diagram showing the principle upon which the comparative indicators operate. M, positive and negative, are the distributing circuit or mains. 1, positive and negative, and 2, positive and negative, are feeding circuits or feeders. Where feeding circuit No. 2 joins the distributing circuit a pressure indicator I is connected, by reference to which the pressure at that point is kept at the desired point. C is the differential galvanometer of the "Comparative Indicator," connected as shown—one coil from 3 to 4 and one from 5 to 6. If the points 3 and 4 are at the same potential and the points 5 and 6 are also at the same potential, then the difference of potentials, or pressure, at end of feeder 1 is the same as at end of feeder 2. No current will flow from 3 to 4 or from 5 to 6, and the comparative indicator will remain on zero. Suppose the point 5 to be at the same potential as the point 6, while the point 3 is at a different potential from the point 4, then there will be a current in the coil connecting 3 and 4, and the comparative indicator will show a deflection one way or the other, depending on whether 3 is higher or lower than the point 4. The comparative indicator thus giving a deflection under these conditions, shows at the station that the pressure at end of feeder 1 is not the same as at end of feeder 2. If, now, the wire of feeder 1 is adjusted until 3 is at same potential as 4, the comparative indicator will come to zero, as it should, for then the pressures at ends of 1 and 2 are equal. Instead of adjusting the positive wire of feeder 1, the negative wire of feeder 1 may be adjusted and the comparative indicator brought to zero. When it is brought to zero in this way the point 5 is made just as much higher or lower than 6 as 3 is higher or lower than 4; then currents will flow in both coils of C, but they will be equal and balance each other, and the comparative indicator will remain on zero, as it should, as the difference of potentials, or pressure, at the two feeder ends is the same.

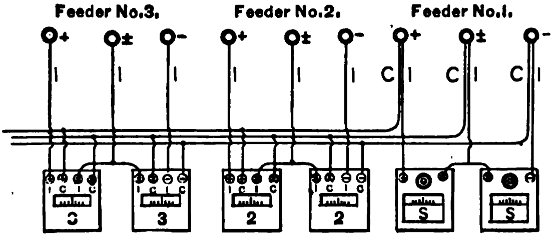


Fig. 14.

Fig. 14 shows the pressure wires from three feeders, No. 1, the standard feeder, and two others. From each feeder a set of iron pressure wires is run. These are marked I, and the points on the comparatives to which they are connected are also marked I. From end of feeder No. 1 an extra set of pressure wires is run, called the standard comparative pressure wires, which are of copper, and run to all the comparatives, as shown in Fig. 14. These wires are marked C, and the points on the comparatives to which these wires are connected are also marked C. This is the way the comparatives are connected in all three-wire systems, except that in some systems only one set of pressure wires is used on No. 1 feeder. When connected as here shown, the pressure at ends of feeders 2 and 3 is compared with the pressure at end of feeder No. 1; and when all the comparatives are on zero the pressure at the ends of all three feeders is the same.

PRESSURE WIRES ON STANDARD FEEDER.

The standard comparative pressure wires connect all the comparatives with the standard point. The pressure, at the feeder ends, when the comparatives are on zero, is the pressure at this standard point. If these standard comparative pressure wires run to the end of the standard feeder, then, when the comparatives are on zero, all the feeder ends will have the same pressure as the standard feeder end. If, however, only one set of pressure wires is run to the standard feeder and the two pressure indicators, as well as the comparatives, are connected to these, then, when the comparatives are on zero, the pressure at the feeder ends will be lower than at the standard feeder end *by the loss in these pressure wires, caused by the current to the two pressure indicators, due to the resistance of the wires.* If iron pressure wires are used, this drop may be 4 to 10 volts; if only one set of pressure wires are used, each wire must measure less than 5 ohms, or the drop will be noticeable.

If the pressure wires have a resistance of 4 ohms, there will be a loss of about 1 volt in them. Under these conditions it is a good practice to use one set of pressure wires. The two pressure indicators can be adjusted *at the feeder end pressure*, and a voltmeter connected around either indicator should show the feeder end pressure without disconnecting the indicators. Scales can be marked on the two pressure indicators; and the scale reading will be the pressure at feeder ends. Under these conditions the pressure at the standard feeder ends will be about one volt higher than the standardizing pressure. The pressure at the other feeder ends will, however, be the same as the standardizing pressure. This simplifies standardizing, as it is not necessary to allow for loss in pressure wires.

INSPECTION OF COMPARATIVE INDICATORS.

The comparative indicators in a station may be inspected at any time and their indications verified by observing the following directions:

On each comparative there are four binding posts, which we will number 1, 2, 3, 4, beginning at the left. In connection with 1 and 4 there are plug switches. These four binding posts are now marked I, C, I, C, in this order. Formerly the posts now marked I, were marked No., and those now marked C, were Std., and in these the *order now observed was not observed*, so that No. 1 may have been marked Std., and No. 2 marked No., or *vice versa*, also 3 and 4 the same. 1 and 2 were never marked the same, nor 3 and 4 the same. Posts 1 and 2 are the ends of one coil, and posts 3 and 4 are the ends of the other coil.

The posts marked C+ (or Std.+) should be connected to the standard + pressure wire. The post marked C± (or Std.±) should be connected to the standard ± pressure wire. The posts marked C– (or Std.–) should be connected to the standard – pressure wire. The posts marked $\overset{\text{I}}{+}\ \overset{\text{I}}{\pm}\ \overset{\text{I.}}{-}$ or $\left\{\overset{\text{No.}}{+}\ \overset{\text{No.}}{\pm}\ \overset{\text{No.}}{-}\right\}$ should be connected to the + ± or – pressure wires from the feeder regulated by that comparative.

To test the coils of the indicator, remove the plugs in 1 and 4. Take a common telephone battery and connect one wire to post No. 2, and the other to post No. 1, *below plug hole*, the needle or pointer should move half a large division on the scale. Then connect the battery to post No. 3, and the other wire to No. 4 *below the plug hole;* this should also move the pointer half a large division on the scale. If in either case the pointer does not move at all, the circuit in that coil is broken, and the binding posts must be tightened up to see that there is a good connection in them; also look at connection inside box to see that they are all right. If the circuit is broken inside the coil send it to us to repair, as unless the wires are put back to the same posts they were connected to the indicator will not indicate right. This is a very rare fault and one that is not at all likely to be found. If, when the battery is connected as above described, the pointer moves over one large division of the scale, it moves too much, and the directing magnet must be strengthened. Take off the cover of the box, and the magnet comes with it; strengthen this magnet, by rubbing it on the poles of a dynamo when it is charged. This is a common fault, as in a dynamo room the magnets are apt to lose their magnetism and need occasional re-magnetization.

TO TEST THE PRESSURE WIRES.

First. The standard pressure wires.

Connect a lamp to the two posts marked C (or Std.) on a comparative on the positive side. Then connect the lamp to the two posts marked C (or Std.) on a negative comparative; if the lamps light up in both cases, the pressure wires are not broken; if it does not light up, look for broken pressure wires on the standard feeder. The other pressure wires are tested the same way, go to *every comparative* and connect the lamps to the two posts marked 1 (or No.), it should light in every case, and if it does not light, look for a broken pressure wire on that feeder.

If a pressure wire is crossed with a feeder wire of the same polarity between the station and feeder end this test will not show it. If the pressure at a feeder end is low when the comparative is on zero, look for a cross of this kind.

TO DETERMINE WHETHER OR NOT THE COMPARATIVES ARE CONNECTED PROPERLY.

When comparatives are first set up the plugs should be taken out, and the connections to the pressure wires made. If when any plug is put in, a violent deflection of the pointer is observed, that coil is connected to wires of different polarity and the connections must be changed, as the two ends of each coil must be connected to the wires of the same polarity.

Connect a 32 candle lamp to the two posts marked C (or Std.) on any comparative, this should produce a deflection on *every comparative.*

Connect the lamp to the two posts marked I (or No.) on *every comparative.* In each case a deflection should be produced on this comparative, and also, on the comparative on the other side of this feeder, in a three-wire system, *but on no other comparative.* If in any case a deflection is produced on other comparatives, the one to which the lamp is connected is wrongly connected, a C. wire being in a post marked I.

Bring the comparatives to zero by the equalizer, connect the voltmeter to the two posts marked C (or Std.) and take a reading; now connect the voltmeter to the two posts marked I (or No.) and take a reading; these two readings should be the same if the comparative is kept on zero all the time by the equalizer. If one is found in which the two readings differ more than one volt it will probably be found that the pressure wires are not connected to the proper posts on the comparative.

If the pointer of a comparative moves sluggishly, and if when it is set swinging by a magnetized screw driver it swings only once or twice before coming to rest, take out pointer and support by removing the little screw in front of galvanometer, and drawing out pointer and support, and sharpen the needle point if it be dull or rusty. Indicators on a wall or other support that constantly vibrates will often work slowly from this cause, as the vibration dulls the needle point, unless it is very hard and perfect.

INSULATION OF PRESSURE WIRES.

Each coil in a comparative indicator is connected to the same distributing wire, or main, at the ends of two feeders. The resistance of each coil of a comparative is about 2,500 ohms. If one of the pressure wires, leading to a comparative, gets crossed with a wire of a different polarity, it causes either 100 or 200 volts to act on that coil to which the pressure wire leads; this gradually heats the coil, and in half an hour or so the coil gets so hot that the insulation is burned off, and the comparative is rendered useless.

If a neutral pressure wire gets crossed on one of the outside wires it will burn out the neutral coils in the two comparatives connected to this feeder.

If the positive or negative pressure wire from the standard feeder, which connects with the comparatives, gets crossed with a wire of different polarity, all the positive or all the negative comparatives will be burned out.

If the neutral pressure wires from standard feeder which connects with the comparatives gets crossed, then *every comparative* will be burned out unless they are disconnected.

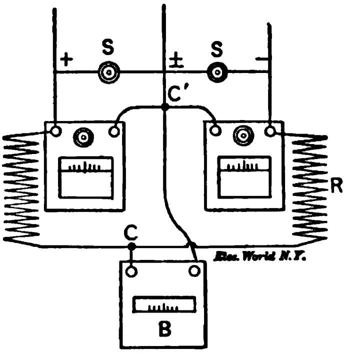
These crosses on the pressure wires do not burn out the comparatives suddenly, as it takes fully half an hour for heat enough to accumulate to burn the insulation, and during this half hour the pointer of the indicator is violently deflected. Therefore, when such a deflection is observed, the plugs in the comparative may be taken out and the instrument saved. It is better to insulate the pressure wires with a good waterproof insulation, especially those on the standard feeder, then a cross will do no damage.

If a non-waterproof insulation be used it will not answer, as, on a wet day, if the wire gets across a bare wire, enough current will leak through the insulation to burn out a coil if it flows for one hour.

THE BALANCE INDICATOR.

The Edison three-wire system is made up of two multiple-arc systems, connected in series with the wire which is common to both systems, connected to the source of current in such a way as to give each of the two systems all the advantages of a simple multiple-arc system. While these two systems (they are called the two sides of "the three-wire system") are intimately associated, (the same current being used in both); they are almost absolutely independent as far as regulation is concerned. The two systems, or sides, have separate indicating and regulating apparatus, and the regulation of each side is performed without any reference to the other. As most customers get part of their lamps from each side, it is very necessary that the pressure on both sides be the same, otherwise a difference in the brightness of the lamps on the two sides will be noticed.

It is the function of the balance indicator to show, at any time, whether or not the pressures on the two sides of the system are the same. Fig. 15 is a diagram showing the principle upon which it operates.



Elec. World N.Y.

FIG. 15.

(Balance Indicator, Patented November 8, 1887.)

The cut shows a pair of pressure indicators, connected to the pressure wires from a feeder end on three-wire system.
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R, R′ are two *equal* high resistances; B is a simple galvanometer. R, R′ and B, connected as shown, or directly to the three-wire circuit, are known as a balance indicator. Its function is to show whether or not the pressures on the two sides of the system are the same.

The point C is electrically midway between the positive and negative wires, and its potential is half-way between the potentials of those wires. When the pressures on the two sides at this point are the same, the potential of C′ is also midway between the potentials of the positive and negative wires; then the points C and C′ are at the same potential and no current flows through B, so it remains on zero. If, however, the pressures on the two sides are not the same, then the potential of C′ is not midway between the potentials of the positive and negative wires, and C and C′ are not at the same potential, consequently, a current flows in B which deflects the needle; the direction of deflection shows which side is highest.

On a three-wire system using the comparative method of indicating pressures, only two absolute pressure indicators are used, one on each side of the system. If one of these changes the pressure on all that side changes, as the comparatives simply copy the pressure kept by this indicator. If, however, a balance indicator is connected around the two indicators, any change in either one of them is immediately shown, and can be remedied. S S in the cut show lamp sockets. If at any time it is necessary to take down one of the two pressure indicators, screw the lamp from this indicator in the socket above the indicator taken out and regulate the pressures by one pressure indicator and the balance indicator, the one pressure indicator holding the desired pressure on one side, and the balance indicator showing when it is the same on the other side.

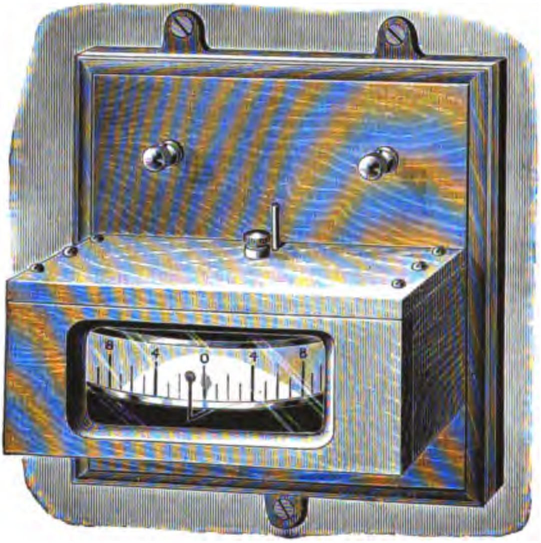

FIG. 16.

Fig. 16 shows the galvanometer used for the balance indicator. It is also used in throwing dynamos in circuit.

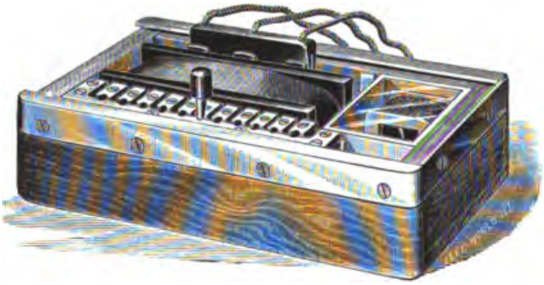

Fig. 17.

THE POCKET BALANCE INDICATOR.

This is a balance indicator in a small box, which can be carried in the pocket. It is for inspectors' use in determining the balance at any part of a three-wire system. A bad balance is the most common cause of unequal pressures in a

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system. This instrument locates the unbalanced parts of the circuit readily, and gives directly what otherwise requires two readings on the voltmeter to show, namely, the amount by which one side is higher than the other.

MAGNETIC SHIELD FOR INDICATOR.

This is a soft iron box which encloses the galvanometer of an indicator, and shields it from the influence of outside magnetic fields. It can be applied to pressure indicators, comparative indicators or balance indicators.

The magnetic shield can be placed in any indicator numbered higher than 400. They are very easily put in place, and full directions are sent with them. This shield does not protect the indicator *entirely* from strong magnetic fields but does so to a very large degree, and it enables us to use indicators, where, without the shield, it would be impossible to do so. The shield, however, is not a perfect shield, and even with a shield in the indicator it is advisable to keep the indicator 5 or 6 feet from the dynamo, and 2 or 3 feet from very heavy currents.

1889.

CATALOGUE OF LAMPS

MANUFACTURED BY

THE EDISON LAMP COMPANY,

OF

HARRISON, N. J.

INTRODUCTION.

THOMAS ALVA EDISON, in the year 1878, in his laboratory, situated at Menlo Park, New Jersey, commenced the manufacture of incandescent lamps.

In 1880 Mr. EDISON formed a partnership with some of his old associates, who had been with him at the laboratory, and erected a factory at Menlo Park, to be exclusively devoted to the manufacture of incandescent lamps. In less than one year this factory was found to be insufficient to supply the demand for EDISON lamps.

The property at Harrison, New Jersey, which is now occupied by THE EDISON LAMP CO., was purchased in the year 1881. The buildings at that time were tenfold larger than needed. Mr. EDISON at that early day felt so certain of the ultimate success of incandescent lighting that he generously provided for the successful future, which has since been realized.

THE EDISON LAMP CO. is the full successor of Mr. EDISON, in the manufacture of incandescent lamps, and is, therefore, *the oldest manufacturer of such lamps in the world, as well as the largest.*

Mr. EDISON has given from the inception of the business, and still continues to give, a large share of his personal attention to the manufacture of his lamps as carried on in the factory of the Edison Lamp Co., at Harrison, New Jersey. He is constantly consulted regarding the methods used; and no change is made in the manufacture, except with his consent; *thus, the lamps made by* The Edison Lamp Company of Harrison, New Jersey, *are manufactured under the direct personal supervision of* Thomas A. Edison.

It is the intention of The Edison Lamp Company to make lamps of all required commercial candle powers, and it is believed by the Company that the types fixed upon in this catalogue cover all that are needed.

The Edison Lamp Company claims that the lamps thus made under Mr. Edison's personal supervision are, for commercial incandescent lighting, The Best Made in the World.

This claim does not rest upon competitive trials, although the Edison Lamp Company has been the successful victor in every one made; but it rests upon the commercial fact that more than a million lamps are in active use to-day, manufactured by The Edison Lamp Company; and this enormous number in the hands of consumers without there being one well-founded complaint regarding the quality of lamps.

In the future The Edison Lamp Company proposes to lead the World, by making the best electric incandescent lamp. In order that the best methods of accomplishing this result may be reached experiments are now being carried on, and will continue to be carried on, on a scale more liberal than ever before.

A large portion of Mr. Edison's magnificent new laboratory in Orange, New Jersey, is now devoted to experimental work upon lamps, and much of Mr. Edison's time is also given to this investigation, with the assistance of the corps of men who have been connected with The Edison Lamp Company in experimental work for many years,

The Edison Lamp Company offer in the following pages a description of the various types of lamps made by them.

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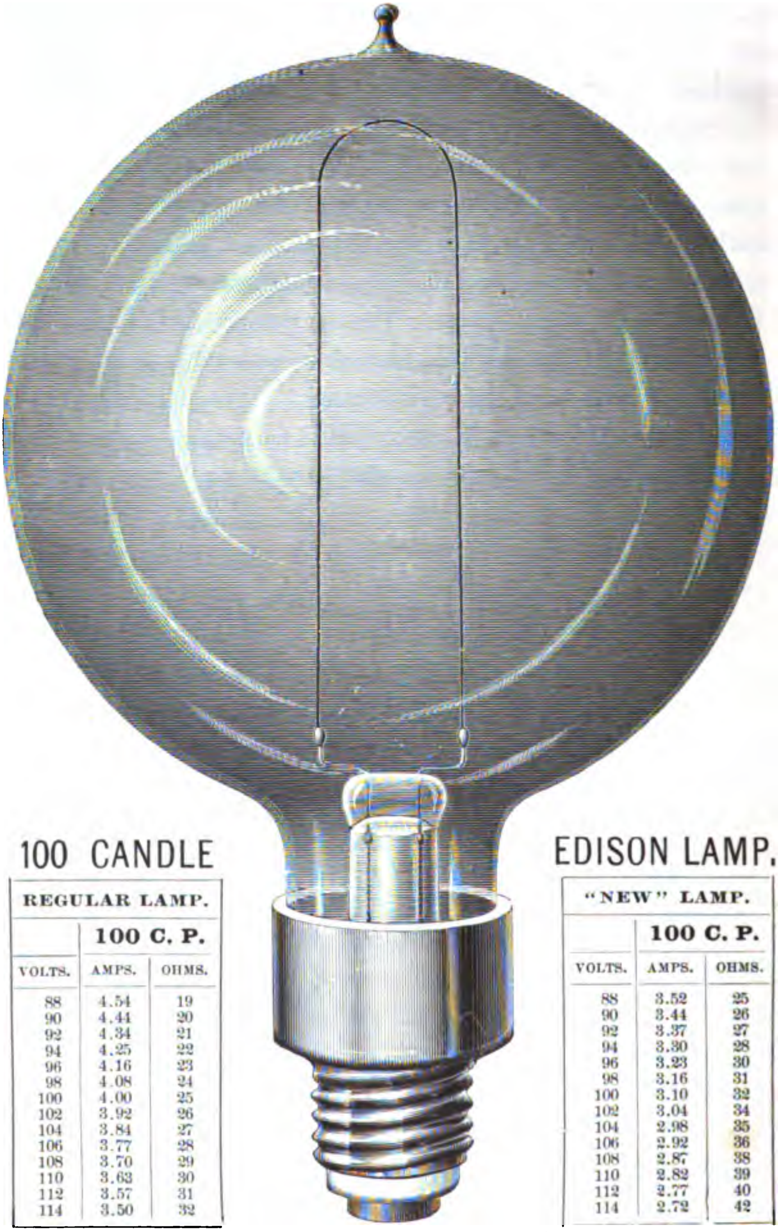
The so-called "New" lamp represents the latest improvements in the manufacture of incandescent lamps.

The tables show, approximately, what may be expected on very large numbers of lamps. It is now fully recognized that the difficulties in obtaining exactness in the manufacture of incandescent lamps—making each lamp the same—are very great, and that only average exactness can be expected. For example: the resistances of the carbon will vary with its cross-section, and a variation which cannot be appreciated by any ordinary gauge, will vary the resistance several ohms. The resistances also depend upon the quality of the carbon, and this will vary slightly from various accidents in the manufacture. These tables represent the ideal which THE EDISON LAMP COMPANY is striving to attain, and are for all practical purposes exact.

EDISON INCANDESCENT ELECTRIC LAMPS



100 CANDLE EDISON LAMP.

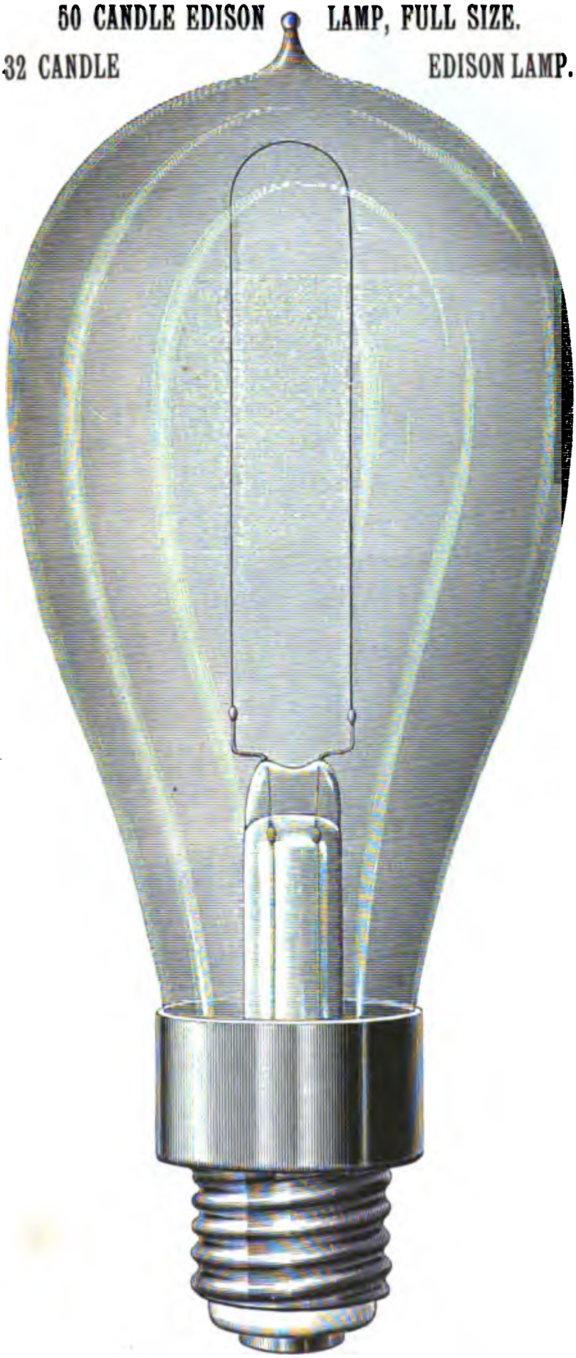
REGULAR LAMP.		
	100 C. P.	
VOLTS.	AMPS.	OHMS.
88	4.54	19
90	4.44	20
92	4.34	21
94	4.25	22
96	4.16	23
98	4.08	24
100	4.00	25
102	3.92	26
104	3.84	27
106	3.77	28
108	3.70	29
110	3.63	30
112	3.57	31
114	3.50	32

"NEW" LAMP.		
	100 C. P.	
VOLTS.	AMPS.	OHMS.
88	3.52	25
90	3.44	26
92	3.37	27
94	3.30	28
96	3.23	30
98	3.16	31
100	3.10	32
102	3.04	34
104	2.98	35
106	2.92	36
108	2.87	38
110	2.82	39
112	2.77	40
114	2.72	42

FOUR-FIFTHS ACTUAL SIZE.

50 CANDLE EDISON LAMP, FULL SIZE.

32 CANDLE EDISON LAMP.



REGULAR LAMPS.

	32 C. P.	
VOLTS.	AMPS.	OHMS.
88	1.60	55
90	1.56	57
92	1.53	60
94	1.49	62
96	1.46	65
98	1.43	68
100	1.40	71
102	1.37	74
104	1.35	76
106	1.32	79
108	1.30	82
110	1.28	85
112	1.26	88
114	1.23	92

REGULAR LAMPS.

	50 C. P.	
VOLTS.	AMPS.	OHMS.
88	2.38	36
90	2.33	38
92	2.28	40
94	2.23	42
96	2.18	43
98	2.14	45
100	2.10	47
102	2.05	49
104	2.01	51
106	1.98	53
108	1.94	55
110	1.90	57
112	1.87	59
114	1.84	61

NEW LAMPS.

	32 C. P.	
VOLTS.	AMPS.	OHMS.
88	1.13	78
90	1.10	82
92	1.08	85
94	1.06	89
96	1.03	93
98	1.01	97
100	.99	100
102	.97	104
104	.95	109
106	.93	113
108	.91	117
110	.90	122
112	.88	126
114	.87	132

NEW LAMPS.

	50 C. P.	
VOLTS.	AMPS.	OHMS.
88	1.76	50
90	1.72	52
92	1.68	55
94	1.64	58
96	1.61	60
98	1.58	63
100	1.55	65
102	1.52	67
104	1.49	70
106	1.46	73
108	1.44	75
110	1.41	78
112	1.38	81
114	1.36	84

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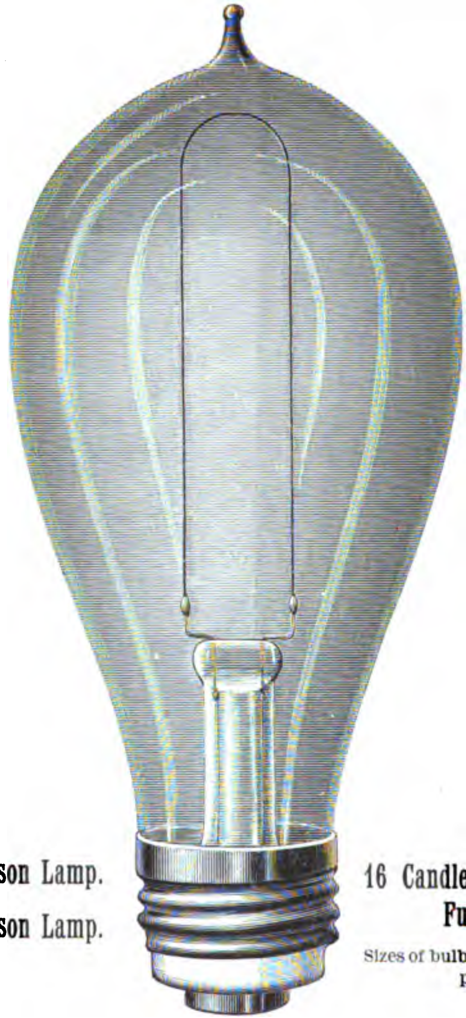


24 Candle Edison Lamp.

20 Candle Edison Lamp.

16 Candle Edison Lamp, Full Size.

Sizes of bulbs vary with candle-powers.

REGULAR LAMPS.

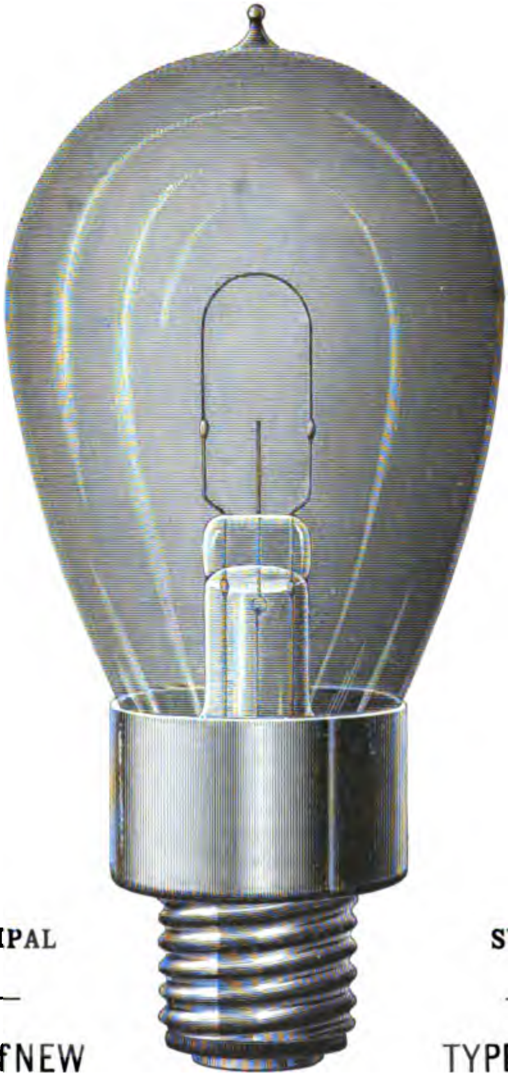
	16 C. P.		20 C. P.		24 C. P.	
VOLTS	AMPS.	OHMS.	AMPS.	OHMS.	AMPS.	OHMS.
88	.82	107	1.02	86	1.22	71
90	.80	112	1.00	90	1.20	75
92	.78	117	.98	94	1.17	78
94	.76	122	.95	98	1.14	81
96	.75	128	.93	102	1.12	85
98	.73	133	.92	106	1.10	88
100	.72	138	.90	111	1.08	92
102	.70	144	.88	115	1.05	96
104	.69	150	.86	120	1.03	100
106	.68	156	.85	125	1.01	104
108	.66	162	.83	129	1.00	108
110	.65	168	.82	134	.98	112
112	.64	174	.80	138	.96	116
114	.63	180	.79	144	.94	120

NEW LAMPS.

	16 C. P.		20 C.P.		24 C.P.	
VOLTS	AMPS.	OHMS.	AMPS.	OHMS.	AMPS.	OHMS.
88	.56	156	.70	125	.84	104
90	.55	163	.68	181	.82	109
92	.53	170	.67	136	.80	114
94	.52	178	.66	142	.79	119
96	.51	186	.64	149	.77	124
98	.50	194	.63	155	.75	129
100	.49	201	.62	161	.74	134
102	.48	209	.60	168	.72	139
104	.47	218	.59	174	.71	145
106	.46	227	.58	181	.70	151
108	.45	235	.57	188	.68	157
110	.45	244	.56	195	.67	163
112	.44	253	.55	202	.66	169
114	.43	262	.54	210	.65	175

EDISON MUNICIPAL LAMPS.

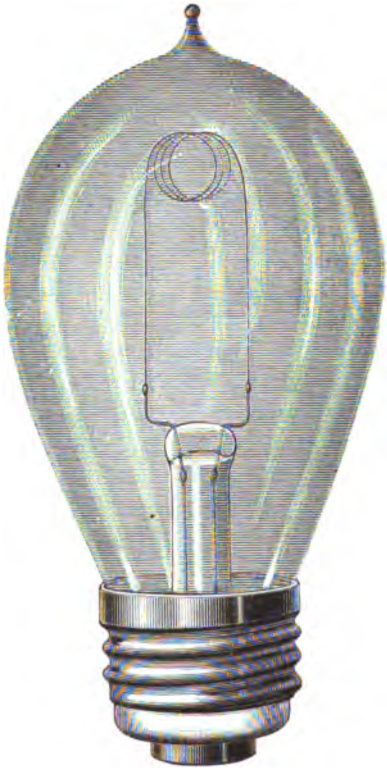
15, 20, 25, 30 AND 50 CANDLE



MUNICIPAL SYSTEM.

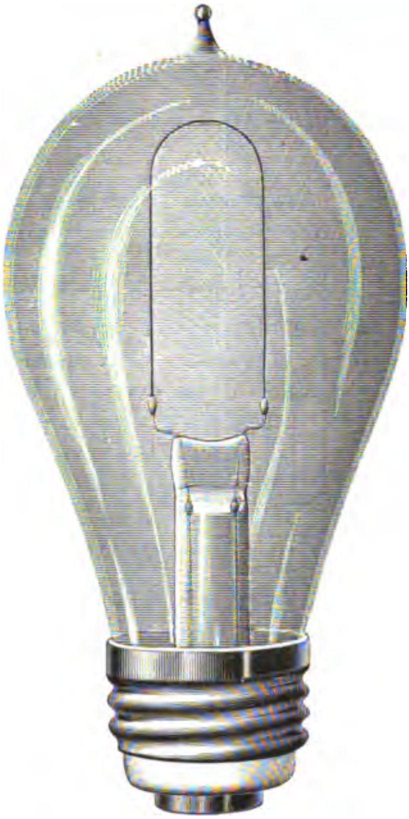
TABLE of NEW TYPE LAMPS.

Amperes.	15 C. P.		20 C. P.		25 C. P.		30 C. P.		50 C. P.	
	VOLTS.	OHMS.	VOLTS.	OHMS.	VOLTS.	OHMS.	VOLTS.	OHMS.	VOLTS.	OHMS.
.6	17.3	6.6	23.1	8.9	28.8	11.9	34.6	13.3	57.6	22.2
2.7	16.7	6.2	22.2	8.2	27.7	10.3	33.3	12.3	55.5	20.5
2.8	16.1	5.7	21.4	7.6	26.7	9.5	32.1	11.4	53.5	19.1
2.9	15.5	5.3	20.7	7.1	25.8	8.9	31.0	10.7	51.7	17.8
3.0	15.	5.0	20.0	6.6	25.0	8.3	30.0	10.0	50.0	16.6
3.1	14.5	4.7	19.3	6.2	24.2	7.8	29.0	9.3	48.3	15.6
3.2	14.	4.4	18.7	5.8	23.4	7.3	28.1	8.8	46.8	14.6
3.3	13.6	4.1	18.1	5.5	22.7	6.9	27.2	8.2	45.4	13.8
3.4	13.2	3.9	17.6	5.2	22.0	6.5	26.4	7.8	44.1	12.9



COILED NIGHT LAMP.

These Lamps give one candle on the usual central station circuit and take two-tenths ampere. They are used in residences, or where a small light is left burning all night.



8 AND 16 CANDLE EDISON B LAMPS.
16 CANDLE STORAGE BATTERY LAMPS.

B-LAMPS.

	8 C. P.		16 C. P.	
VOLTS	AMPS.	OHMS.	AMPS.	OMHS.
46	.78	58	1.56	29
48	.75	64	1.50	32
50	.72	69	1.44	34
52	.69	75	1.38	37
54	.66	81	1.33	40
56	.64	87	1.28	43

STORAGE BATTERY LAMPS.

3 WATTS PER CANDLE POWER.

	12 Candles.		16 Candles.		21 Candles.		28 Candles.	
VOLTS	AMPS.	OHMS.	AMPS.	OHMS.	AMPS.	OHMS.	AMPS.	OHMS.
58	.62	93	.82	70	1.08	53	1.48	40
59	.61	96	.81	72	1.07	55	1.42	41
60	.60	100	.80	75	1.05	57	1.40	43
61	.59	103	.79	77	1.03	59	1.38	44
62	.58	107	.77	80	1.01	61	1.35	46

BATTERY LAMPS—CONTINUED.

LAMPS 20 TO 40 VOLTS AT 3 WATTS PER CANDLE POWER.

VOLTS.	12 Candles.		16 Candles.		21 Candles.		28 Candles.	
	AMPERES.	OHMS.	AMPERES.	OHMS.	AMPERES.	OHMS.	AMPERES.	OHMS.
20	1.80	11.1	2.40	8.3	3.15	6.3	4.20	4.7
21	1.71	12.3	2.29	9.2	3.00	7.	4.00	5.3
22	1.63	13.6	2.19	10.1	2.85	7.7	3.81	5.8
23	1.56	14.8	2.09	11.	2.72	8.4	3.65	6.3
24	1.50	16.	2.00	12.	2.62	9.1	3.50	6.8

VOLTS.	12 Candles.		16 Candles.		21 Candles.		28 Candles.	
	AMPERES.	OHMS.	AMPERES.	OHMS.	AMPERES.	OHMS.	AMPERES.	OHMS.
28	1.28	21.	1.71	16.3	2.25	12.6	3.00	9.3
29	1.24	23.	1.65	17.5	2.18	13.4	2.90	10.0
30	1.20	25.	1.60	18.7	2.10	14.2	2.80	10.7
31	1.16	27.	1.55	20.	2.03	15.2	2.71	11.4
32	1.12	29.	1.50	21.3	1.96	16.5	2.62	12.1

VOLTS.	12 Candles.		16 Candles.		21 Candles.		28 Candles.	
	AMPERES.	OHMS.	AMPERES.	OHMS.	AMPERES.	OHMS.	AMPERES.	OHMS.
36	1.00	36.	1.33	27.	1.75	20.5	2.33	15.6
37	.97	38.	1.29	28.5	1.70	21.6	2.27	16.4
38	.94	40.	1.26	30.1	1.66	22.8	2.21	17.2
39	.92	42.	1.23	31.7	1.61	24.1	2.16	18.1
40	.90	44.	1.20	33.3	1.57	25.4	2.10	19.0

LAMPS 20 TO 40 VOLTS AT 2½ WATTS PER CANDLE-POWER.

These Lamps will last only one-third as long as those at 3 Watts per candle-power.

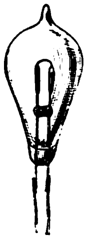
VOLTS.	16 Candles.		21 Candles.		28 Candles.		36 Candles.	
	AMPERES.	OHMS.	AMPERES.	OHMS.	AMPERES.	OHMS.	AMPERES.	OHMS.
20	2.00	10.	2.62	7.6	3.50	5.7	4.50	4.4
21	1.90	11.	2.49	8.5	3.34	6.3	4.28	4.9
22	1.81	12.1	2.36	9.3	3.18	6.9	4.10	5.3
23	1.73	13.3	2.27	10.	3.04	7.5	3.91	5.8
24	1.66	14.4	2.18	10.8	2.91	8.2	3.75	6.4

VOLTS.	16 Candles.		21 Candles.		28 Candles.		36 Candles.	
	AMPERES.	OHMS.	AMPERES.	OHMS.	AMPERES.	OHMS.	AMPERES.	OHMS.
28	1.43	19.5	1.87	15.	2.50	11.2	3.21	8.7
29	1.38	21.	1.81	16.	2.41	12.	3.10	9.4
30	1.33	22.5	1.75	17.	2.33	12.8	3.00	10.
31	1.29	24.	1.69	18.1	2.25	13.7	2.90	10.7
32	1.25	25.6	1.64	19.4	2.18	14.6	2.81	11.4

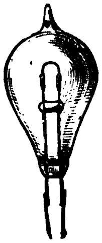
VOLTS.	16 Candles.		21 Candles.		28 Candles.		36 Candles.	
	AMPERES.	OHMS.	AMPERES.	OHMS.	AMPERES.	OHMS.	AMPERES.	OHMS.
36	1.11	32.4	1.46	24.6	1.94	18.5	2.50	44.4
37	1.08	34.3	1.41	26.1	1.89	19.5	2.43	15.2
38	1.05	36.2	1.37	27.7	1.84	20.6	2.37	16.
39	1.02	38.1	1.34	29.1	1.79	21.7	2.31	16.8
40	1.00	40.	1.31	30.5	1.75	22.8	2.25	17.7

SMALL LAMPS FOR BATTERIES.

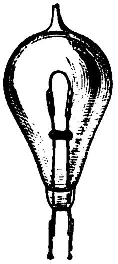
CUTS REPRESENT ACTUAL SIZES.



½-Candle Lamp.

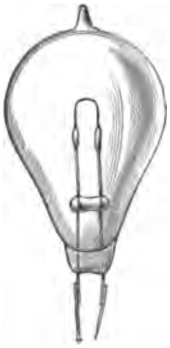


1-Candle Lamp.

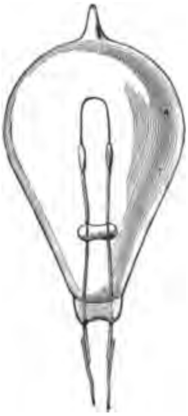


2-Candle Lamp.

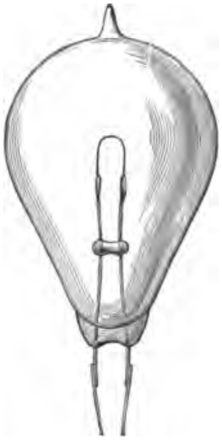
Candle Power.	Resistance. — Ohms.	Electro-Motive Force. — Volts.	Current Required Approx. — Amperes.
½ Candle..................	1.3 to 2	2.5 to 4	1 to 1.50
1 Candle..................	2.9 to 4.5	3.5 to 5.5	1 to 1.50
2 Candles........	3.3 to 5	4.5 to 5.5	1 to 1.50



3-Candle Power Lamp.



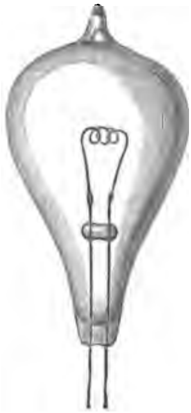
4-Candle Power Lamp.



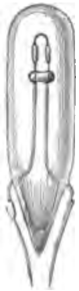
6-Candle Power Lamp.

Candle Power.	Resistance. — Ohms.	Electro-Motive Force. — Volts.	Current Required. Approx. — Amperes.
3 Candles.	3.6 to 4.5	5.5 to 7	1 to 1.50
4 Candles..................	5 to 6.5	7 to 9.5	1 to 1.50
6 Candles-.................	6 to 12	9 to 12	1 to 1.50

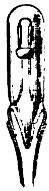
SMALL LAMPS FOR BATTERIES.



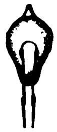
20-CANDLE POWER SPIRAL LAMP.



DENTAL LAMP.



SPECIAL DENTAL LAMP.



PEA LAMP.

DESCRIPTION.	CANDLE POWER.	RESISTANCE, OHMS.	ELECTRO-MOTIVE FORCE. VOLTS.	CURRENT REQUIRED APPROX. AMPERES.
Dental Lamp	⅓ Candle	1.1 to 3.5	2 to 4	1.30
Special Dental	⅓ Candle	1.7 to 2.8	2 to 2.5	1.
Pea Lamp	½ Candle	1.2 to 2	2 to 4	1. 4
Spiral Lamp	20 Candles	25.	30 to 36	1. 3

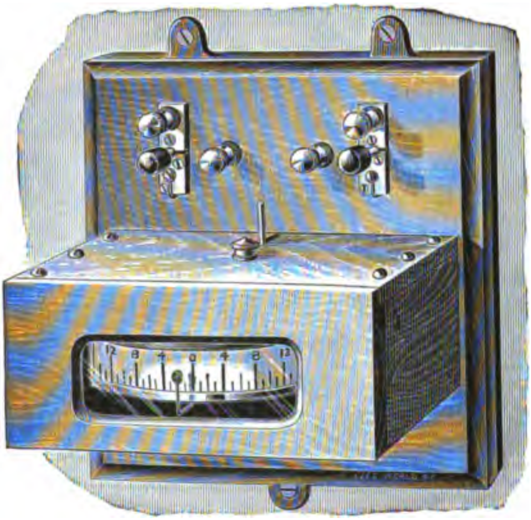
THE EDISON PRESSURE INDICATOR.

The pressure developed by a dynamo is a variable quantity, varying with the speed; and by means of the regulating resistance box it can be adjusted over quite a large range of pressures. The lamps supplied to any plant require a certain fixed, constant pressure, in order to give the best results. To enable the person operating any plant to adjust the pressure at the right point and to keep it always at the right point the pressure indicator is used. The Indicator simply shows when the pressure is right and when it is not right, and by reference to it the dynamo is regulated so it is kept right.

It is important that the indicator be kept in good working order, and that it receives the attention it deserves. The successful and satisfactory operation of an incandescent electric light plant depends upon the maintenance of a constant, correct pressure more than upon any other condition; in fact, this is the one condition that *insures* satisfaction. If the pressure be allowed to rise above the correct pressure, the life of the lamps is very much shortened, as shown in the following table, where it is seen that a rise of 3% in pressure will reduce the lamp life one half.

The action of the pressure indicator depends upon the variation of the resistance of a carbon filament with the current passing through it. The lamps used are specially prepared, and with the small current used in them will remain constant for a very long time. We have records of indicators that have been used continuously, day and night, for sixteen months, that have not changed over one per cent. in their readings. And we believe that the indicators now being made will remain constant for a number of years. The pressure indicator has a scale giving a range of about 25 volts, the scale being made as ordered. It is a zero instrument, the pointer remaining on zero as long as the normal pressure, for which it is adjusted, is acting on the instrument. Any variation in this pressure causes a deflection of the pointer. The scale before which the pointer swings is made of thin paper, and the light from the lamp shines on the back of the paper making it easily seen; the pointer carries a round, black piece of paper on its end, so its position on the scale can easily be seen from a distance. The indicators are adjusted to give a deflection of the pointer of $\frac{1}{8}$ inch for each volt variation from the normal pressure on a 100 volt circuit.

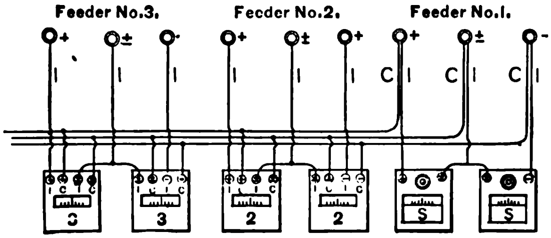
THE COMPARATIVE INDICATOR.



PATENTED NOV. 16, 1886.

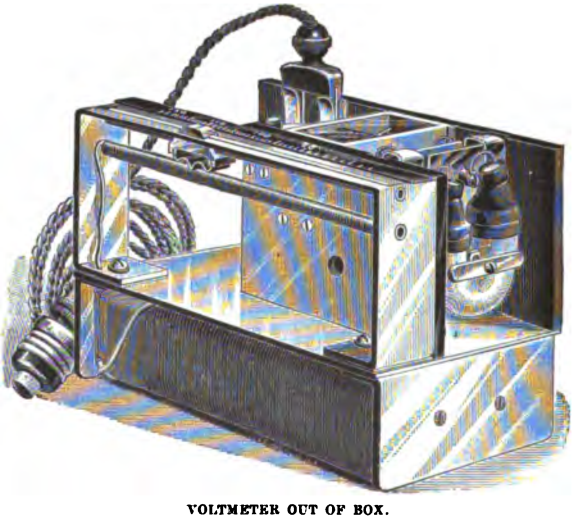
The Comparative Indicator is for use in Edison central stations only. It is used to show whether or not the pressures at the ends of the feeders are the same as the pressure at the end of the standard feeder. The pressure at the end of the standard feeder is maintained at the desired point by reference to a pressure indicator, the comparatives simply show when the pressures at the other feeder ends are the same as the pressure at the standard feeder end.

The pressure wires from standard feeder are connected to the points marked **C** on the comparatives. The pressure wires from the feeder whose pressure is shown by the comparative, are connected to the points marked **I**.



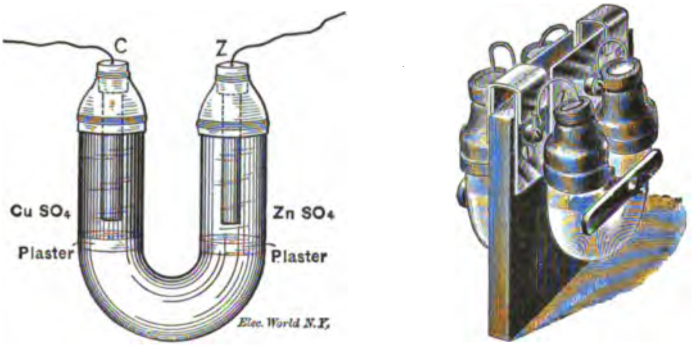
THE BATTERY VOLTMETER.

BOX.



VOLTMETER OUT OF BOX.

The Voltmeter is a portable instrument used for measuring pressures. The potentiometer or opposition method of measurement is employed in it. The circuit which the pressure being measured acts upon is fixed, and another circuit containing a battery of known constant E. M. F. and a galvanometer and switch is connected around a variable part of the first circuit. When the fall of E. M. F. in this variable part of the main circuit is equal to the E. M. F. of the battery, then no current will flow in the galvanometer circuit, and the pressure can be read directly off the scale, which shows the position of the variable contact on the first circuit.



BATTERY PATENTED NOV. 8, 1887.

Two Daniell cells, arranged as shown in the cut, are used in the voltmeter. These cells are air-tight and will last four or five months without attention; when used up they are thrown away and new ones put in their places. By sliding connections the batteries are arranged either in parallel or in series; when in parallel the pressure required to balance the instrument is read directly off the scale, when in series the pressure is known by doubling the scale reading.

When so ordered a special connection is put in the voltmeter by means of which pressures which are half the scale readings, may be measured. The scale usually includes a range of about 40 volts. For Edison stations it is marked from 90 to 135. With the cells in series pressures from 180 to 270 can be read, and with the special connection from 45 to 65 volts. A voltmeter with its scale marked from 40 to 80 can be used for any pressure between 40 and 160.

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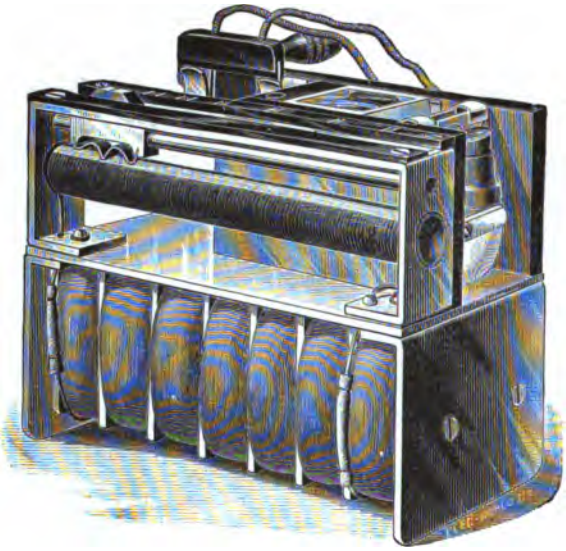
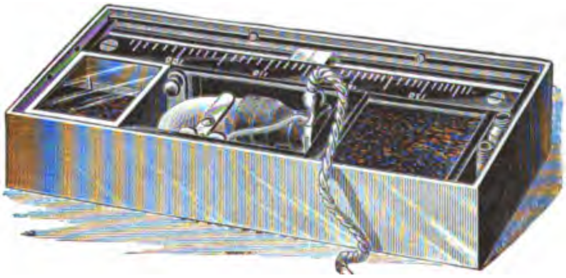


MUNICIPAL VOLTMETER REMOVED FROM BOX.

The Municipal Voltmeter is designed for measuring pressures from 700 to 1,300 volts. It is constructed upon the same principles as the voltmeter just described. Very particular attention is paid to the insulation of this instrument.



POCKET VOLTMETER.

The Pocket Voltmeter is intended for inspector's use, and can readily be carried in the hip-pocket. They are made to read from 90 to 130 volts unless otherwise ordered. The connection for halving the scale reading is put in when ordered.

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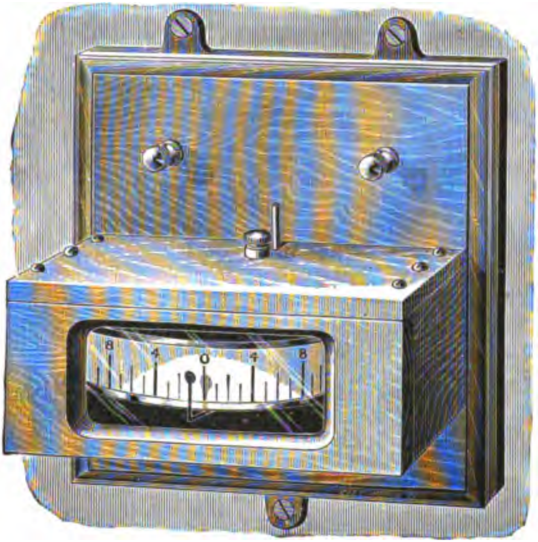
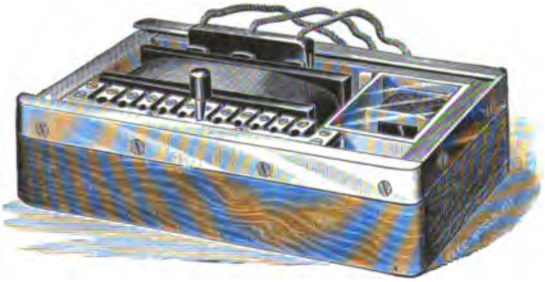


HIGH RESISTANCE GALVANOMETER.

This is a simple galvanometer of 2,500 ohms resistance. It is used in central stations to throw a dynamo in circuit with others without causing a rise or fall in the pressure on the circuit. It is also used in connection with two equal high resistances as a balance indicator, to show any difference in the pressures on the two sides of a three-wire system.



POCKET BALANCE INDICATOR.

This is a pocket form of the balance indicator; it is for inspector's use, and enables him to detect any difference in pressures on the two sides of any three-wire service, thus localizing any bad balance in the system.

CATALOGUE AND PRICE LIST

OF

Edison Incandescent Electric Lamps

◆

EDISON LAMP CO.

Harrison, New Jersey, U. S. A.

NEW YORK:
C. G. BURGOYNE'S PRINTING BUSINESS.
1890.

SPECIAL NOTICE.

◆

Terms cash. Subject to draft in thirty days after shipment of goods.

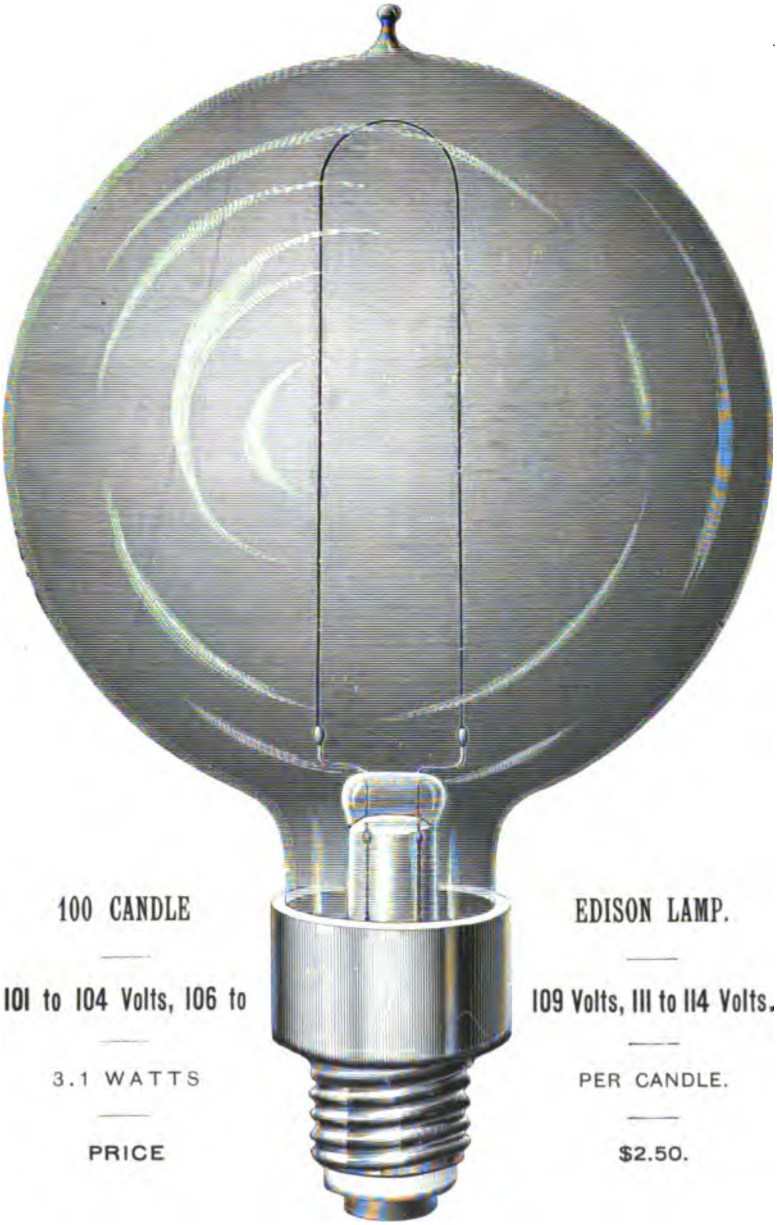
……

Goods shipped at purchaser's risk.

TABLE SHOWING LIVES OF LAMPS AT DIFFERENT E. M. F.

Volts on Lamp.	VOLT AT WHICH LAMP GIVES 16 CANDLES.																				
	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110
90	1000	1318	1732	2269	2965	3863	5020	6504	8406	10834	13929	17864	22853	29165	37134	47170	59784	75600	95396	120000	150920
91	758	1000	1314	1722	2249	2931	3808	4934	6377	8219	10560	13552	17337	22125	28170						
92	577	760	1000	1310	1712	2230	2893	3781	4852	6254	8040	10312	13192	16836	21435						
93	440	580	763	1000	1306	1702	2211	2865	3703	4773	6136	7869	10067	12848	16359						
94	337	444	584	765	1000	1303	1692	2193	2834	3653	4696	6023	7705	9834	12521						
95	258	341	448	587	767	1000	1299	1683	2175	2804	3605	4623	5914	7548	9610						
96	199	262	345	452	590	769	1000	1295	1674	2158	2774	3558	4552	5809	7397						
97	153	202	266	348	455	593	771	1000	1292	1665	2141	2746	3513	4483	5708						
98	119	156	206	270	352	459	597	773	1000	1289	1657	2126	2718	3472	4417						
99	92	121	159	209	273	356	463	600	775	1000	1285	1648	2109	2693	3427	4355					
100	72	94	124	162	212	277	360	467	603	777	1000	1282	1640	2095	2665	3387	4293				
101	55	73	96	127	166	216	281	363	470	606	779	1000	1279	1632	2078	2640	3347	4232			
102	43	57	75	99	129	169	219	284	367	474	609	781	1000	1276	1624	2064	2616	3308	4176		
103	34	45	59	77	101	132	172	223	288	371	477	612	783	1000	1273	1618	2050	2592	3271	4120	
104	26.9	35	46	61	79	103	135	175	226	291	375	480	615	785	1000	1270	1610	2036	2578	3235	4064
105	21.2	27.9	36	48	62	81	106	138	178	230	295	378	484	618	787	1000	1267	1602	2022	2546	3199
106	16.7	22	28.9	37.9	49	64	83	109	140	181	233	298	382	488	621	789	1000	1264	1596	2009	2524
107	13.2	17.4	22.9	30	39.2	50.5	66	85	111	143	184	236	302	386	491	624	792	1000	1262	1589	1996
108	10.4	13.8	18.1	23.7	31	40.4	52	68	88	113	146	187	239	306	389	494	627	794	1000	1260	1582
109	8.3	10.9	14.7	18.8	24.6	32.1	41.7	53.5	69.9	90	115	149	190	242	309	393	497	629	796	1000	1258
110	6.6	8.7	11.4	15	19.6	25.5	33.2	42.4	55	72	92	117	151	193	246	313	396	500	632	798	1000

EDISON INCANDESCENT ELECTRIC LAMPS

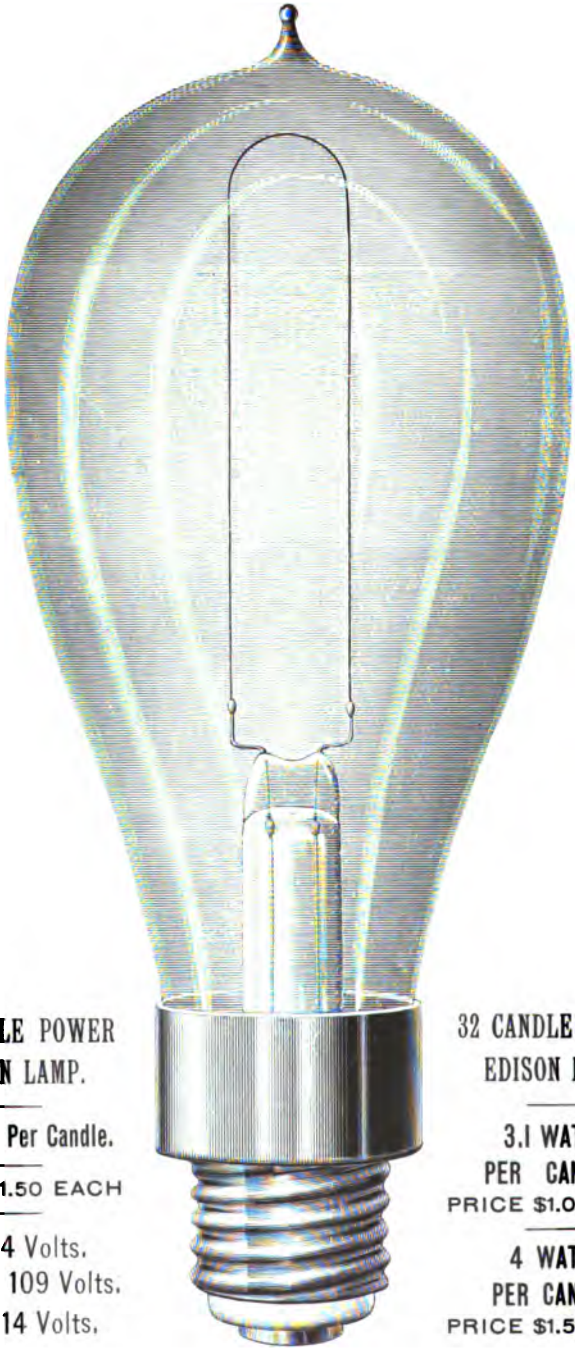


100 CANDLE EDISON LAMP.

101 to 104 Volts, 106 to 109 Volts, 111 to 114 Volts.

3.1 WATTS PER CANDLE.

PRICE $2.50.



50 CANDLE POWER EDISON LAMP.

3.1 Watts Per Candle.

PRICE $1.50 EACH

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101 to 104 Volts.
106 to 109 Volts.
111 to 114 Volts.

32 CANDLE POWER EDISON LAMP.

3.1 WATTS PER CANDLE.

PRICE $1.00 EACH

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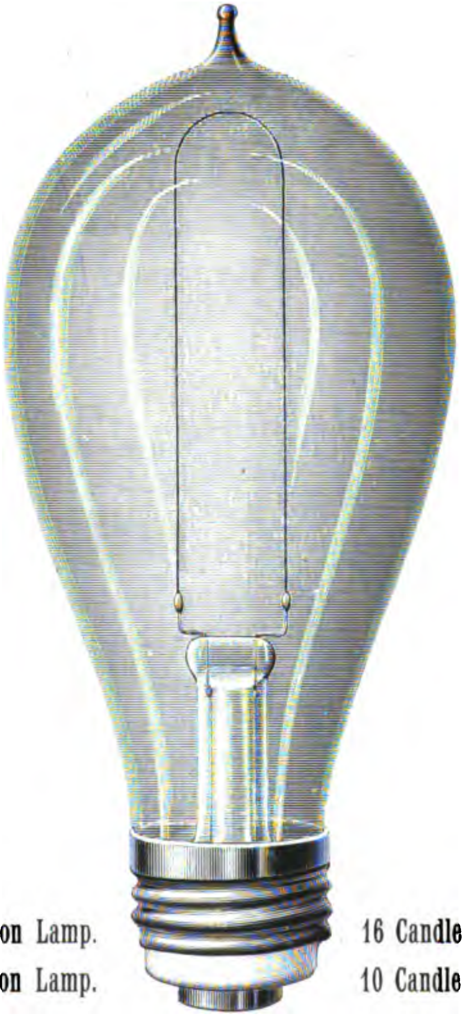
4 WATTS PER CANDLE.

PRICE $1.50 EACH



24 Candle Edison Lamp.

20 Candle Edison Lamp.

16 Candle Edison Lamp.

10 Candle Edison Lamp.

101 TO 104 VOLTS, 106 TO 109 VOLTS, 111 TO 114 VOLTS.

3.1 WATTS PER CANDLE.

16 Candle Power,	75 cents each.
20 " "	75 " "
24 " "	80 " "

3.3 WATTS PER CANDLE.

10 Candle Power,	80 cents each.

3.6 WATTS PER CANDLE.

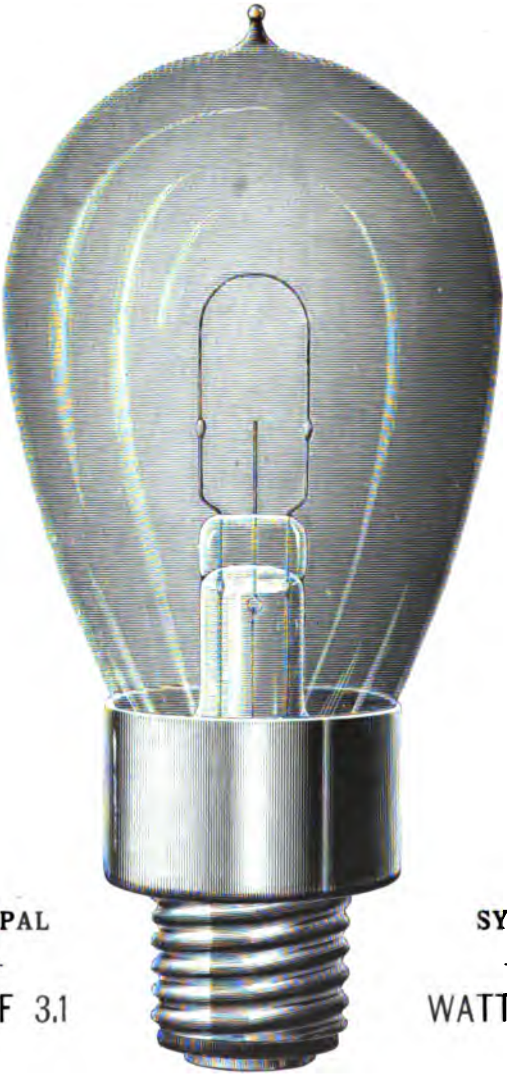
16 Candle Power,	75 cents each.
20 " "	80 " "

4 WATTS PER CANDLE.

10 Candle Power,	75 cents each.
16 " "	80 " "

EDISON MUNICIPAL LAMPS.

15, 20 25 30 AND 50 CANDLE



MUNICIPAL SYSTEM.

TABLE OF 3.1 WATT LAMPS.

2.70 TO 2.95 AMPERES. 3.05 TO 3.25 AMPERES.

PRICES.

15 Candle Power Municipal Lamp,	$1.00
20 " " " "	1.00
25 " " " "	1.00
30 " " " "	1.20
50 " " " "	2.00
100 " " " "	3.00

EDISON LAMPS.

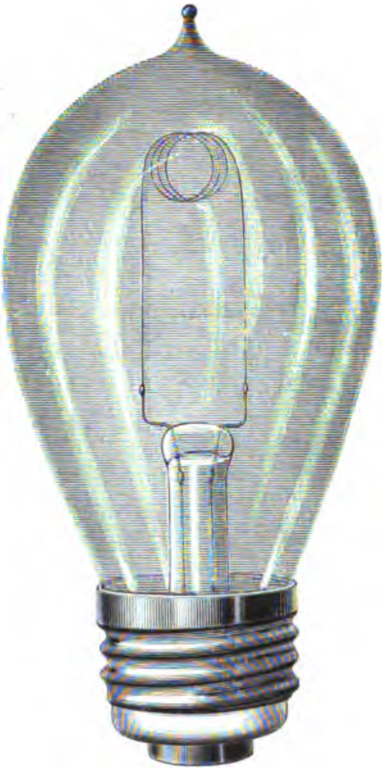
10, 16 AND 32 CANDLE POWER.

3.1 Watts: 47, 48, 49, 51, 52, 53, 57, 58, 59, 61, 62, 63, 64, 66 and 67 Volts.

4 Watts: 73, 74, 76, 77, 78, 82, 83 and 84 Volts.

PRICES:

10 Candle Power,	80 cents	each.
16 " "	75 "	"
32 " "	$1.00	"



COILED NIGHT LAMP.

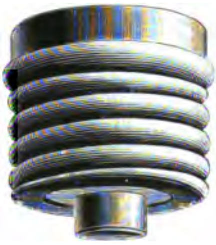
These lamps give one candle on the usual central station circuit and take two-tenths ampere. They are used in residences, or where a small light is left burning all night.

Spiral Night Lamps, ...	$1.20 each.
Straight " "	.80 "

BASES.

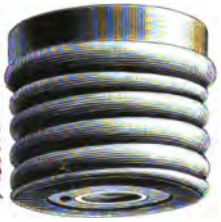
Unless otherwise specified, all lamps will be shipped with No. 1 bases. The other bases, Nos. 2, 3 or 4, will be placed on lamps, when so ordered, without extra charge.

Edison



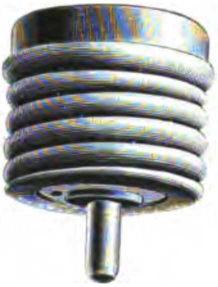
No. 1.

Thomson-Houston



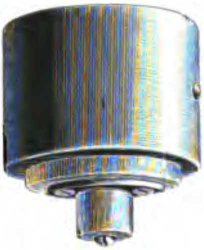
No. 2.

Westinghouse



No. 3.

United States



No. 4

SPECIAL LAMPS.

Prices quoted on application, which should state volts, amperes and candle powers desired.

BATTERY LAMPS.

These Lamps are about same size as cut on page 5, but with shorter carbons.

Lamps 20 to 40 Volts at 3.1 Watts per Candle Power.

VOLTS.	12 Candles.		16 Candles.		21 Candles.		28 Candles.	
	AMPERES.	OHMS.	AMPERES.	OHMS.	AMPERES.	OHMS.	AMPERES.	OHMS.
20	1.86	10.7	2.48	8.06	3.25	6.2	4.34	4.6
21	1.78	11.9	2.36	8.96	3.1	6.8	4.08	5.1
22	1.7	13.	2.25	9.80	2.94	7.45	3.88	5.7
23	1.62	14.2	2.15	10.7	2.82	8.2	3.7	6.2
24	1.55	15.4	2.06	11.6	2.71	8.9	3.54	6.75
28	1.33	21.	1.77	15.8	2.35	11.9	3.08	9.1
29	1.28	22.4	1.71	16.9	2.27	12.8	2.98	9.7
30	1.24	24.19	1.65	18.1	2.2	13.6	2.89	10.4
31	1.20	25.8	1.59	19.3	2.13	14.6	2.8	11.1
32	1.16	27.4	1.54	20.6	2.06	15.6	2.72	11.8
36	1.03	35.00	1.37	26.2	1.83	20.00	2.42	15.
37	1.00	37.00	1.34	27.8	1.77	21.1	2.35	15.8
38	.97	39.00	1.3	29.3	1.72	22.23	2.29	16.6
39	.95	41.00	1.27	30.8	1.67	23.4	2.22	17.5
40	.93	43.01	1.24	32.4	1.62	24.0	2.17	18.4

Lamps 20 to 40 Volts at 2½ Watts per Candle Power.

These Lamps will last only one-third as long as those at 3.1 Watts per Candle Power.

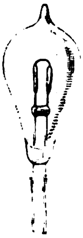
VOLTS.	16 Candles.		21 Candles.		28 Candles.		36 Candles.	
	AMPERES.	OHMS.	AMPERES.	OHMS.	AMPERES.	OHMS.	AMPERES.	OHMS.
20	2.00	10.	2.62	7.6	3.50	5.7	4.50	4.4
21	1.90	11.	2.49	8.5	3.34	6.3	4.28	4.9
22	1.81	12.1	2.36	9.3	3.18	6.9	4.10	5.3
23	1.73	13.3	2.27	10.	3.04	7.5	3.91	5.8
24	1.66	14.4	2.18	10.8	2.91	8.2	3.75	6.4
28	1.43	19.5	1.87	15.	2.50	11.2	3.21	8.7
29	1.38	21.	1.81	16.	2.41	12.	3.10	9.4
30	1.33	22.5	1.75	17.	2.33	12.8	3.00	10.
31	1.29	24.	1.69	18.1	2.25	13.7	2.90	10.7
32	1.25	25.6	1.64	19.4	2.18	14.6	2.81	11.4
36	1.11	32.4	1.46	24.6	1.94	18.5	2.50	14.4
37	1.08	34.3	1.41	26.1	1.89	19.5	2.43	15.2
38	1.05	36.2	1.37	27.7	1.84	20.6	2.37	16.
39	1.02	38.1	1.34	29.1	1.79	21.7	2.31	16.8
40	1.00	40.	1.31	30.5	1.75	22.8	2.25	17.7

PRICES:

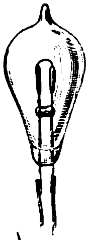
12 Candle Power,	- - - - - - -	80 cents each.
16 " "	- - - - - - -	75 " "
21 " "	- - - - - - -	75 " "
28 " "	- - - - - -	$1.00 "
36 " "	- - - - - -	$1.00 "

Edison Miniature Incandescent Electric Lamps.

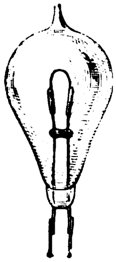
CUTS REPRESENT ACTUAL SIZES.



½-CANDLE LAMP.

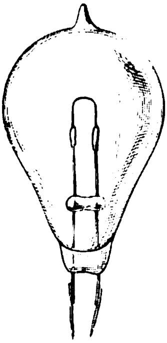


1-CANDLE LAMP.

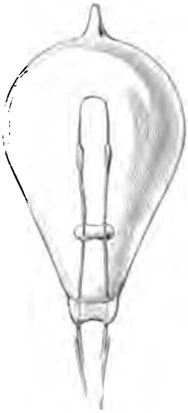


2-CANDLE LAMP.

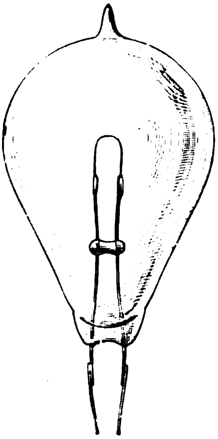
Candle Power.	Resistance. Ohms.	Electro-Motive Force. Volts.	Current Required. Approx. Amperes.	Price Each.	Per Dozen
½ Candle	1.3 to 2	3.0 to 4.5	1 to 1.50	$1 00	$10
1 Candle	2.9 to 4.5	3.5 to 5.5	1 to 1.50	1 00	10
2 Candles	3.3 to 5	4.5 to 5.5	1 to 1.50	1 00	10



3-CANDLE LAMP.



4-CANDLE LAMP.

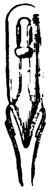


6-CANDLE LAMP.

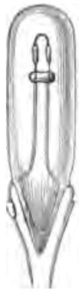
Candle Power.	Resistance. Ohms.	Electro-Motive Force. Volts.	Current Required. Approx. Amperes.	Price Each.	Per Dozen.
3 Candles	3.6 to 4.5	5.5 to 7	1 to 1.50	$1 00	$10
4 Candles	5 to 6.5	7 to 9.5	1 to 1.50	1 00	10
6 Candles	6 to 7	9 to 12	1 to 1.50	1 00	10

SMALL LAMPS FOR DECORATIVE PURPOSES.

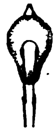
The three and six-candle power small lamps are the ones usually employed for decorations, and we make special series lamps for this purpose, to be operated by station currents, and being made to run eight in series. Central station managers can obtain more details as to these lamps on application.



SPECIAL DENTAL LAMP.



DENTAL LAMP.

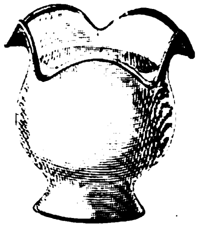


PEA LAMP.

Description.	Candle Power.	Resistance. Ohms.	Electro-Motive Force. Volts.	Current Required. Approx. Amperes.	Price Each.	Per Dozen.
Dental Lamp............	½ Candle	1.1 to 3.5	3 to 4	1.30	$1 00	$12
Special Dental............	⅓ Candle	1.7 to 2.8	3 to 4	1.20	2 00	18
Pea Lamp.................	½ Candle	1.2 to 2	3 to 4	1.40	2 00	18

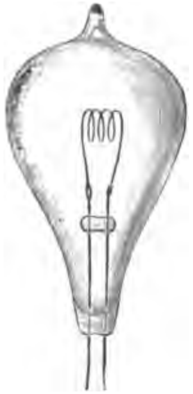
The Edison Spiral Lamp.

20-CANDLE POWER.



SHADE FOR SMALL LAMP.

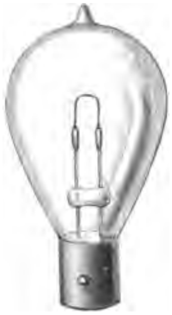
Price 30 Cents Each.



ACTUAL SIZE.

30 to 38 Volts, 1 to 1.75 Amperes, also 55 to 60 Volts.

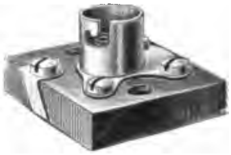
$2.50 Each.



SMALL LAMP WITH BASE.

Extra Charge for Bases on Small Lamps of any C. P.

10 Cents Each.



RECEPTACLE FOR SMALL LAMPS.

Price 40 Cents Each.

EDISON TWO-LAMP PRESSURE INDICATOR.

Place the indicator where it can be easily seen by the man operating the plant. It should be at least six feet from the dynamo or wires carrying heavy currents. Free the pointer by screwing down the pin on back of cover, and level the indicator until the pointer swings freely along its scale. Connect the indicator to the tap supplying the engine room lamps or to the centre of distribution. Set the *upper* sliding index at the mark on its scale corresponding to the pressure you wish to maintain; when the indicator is connected to a tap line the upper sliding index should be set at the mark corresponding to the volts the lamps are made for; if it is connected to the centre of distribution it should be set two or three volts above this.

The lever on the side of the indicator box is for the purpose of throwing either of the two lamps or sliders into circuit. When this lever is pushed to its extreme position toward the back of the indicator the "work" lamp will be lighted, and the lower sliding index will be in circuit. When it is pushed to its extreme position toward the front of the indicator the "test" lamp will be lighted and the upper sliding index will be in circuit. When it is in its central position neither lamp nor sliding index will be in circuit.

The "work" lamp must be kept always in circuit, while the "test" lamp is only intended to be used as a check on the "work" lamp, and is not to be lighted except at times of the test.

TO SET THE INDICATOR.

When the pointer swings freely, the dynamo is running, and neither lamp is lighted, adjust the lever on the top of indicator box until the pointer stands on zero. Then having set the upper sliding index at the point corresponding to the pressure you wish to maintain, draw the lever, on side of box, slowly toward the front until it stops. Then regulate the pressure by the dynamo resistance box until the round dot on pointer stands in centre and the current is steady. Then to set the lower sliding index move the lever, on side of indicator box, slowly backward until it stops, and then move the lower index along its scale until the round dot of pointer stands on zero again. When this has been done, and the current is steady, the swinging pointer will remain in the centre of its scale, while the lever, on side of indicator box, is moved slowly from one stop to the other, showing that the two sliders and lamps agree. This tests the adjustment of the indicator, and should be applied frequently. The swinging pointer should be tested for zero at least once a day, and the "work" lamp checked at least once a week.

If either lamp gets broken, order a new one, always giving the number of the indicator. New indicator lamps are one dollar and fifty cents each.

United Edison Manufacturing Co.

[illegible]

Indicator Shields, - - - - - - - 4 00

Edison Lamps for use in the following Cities may be obtained from the Edison Local Companies named below:

Edison Electric Illuminating Co., Altoona, Penn.
Edison Electric Light & Power Co., Amsterdam, N. Y.
Appleton Edison Light Co., Appleton, Wis.
Edison Electric Illuminating Co., Ashland, Penn.
Electric Light Co., Atlantic City, N. J.
Edison Electric Illuminating Co., Bellefonte, Penn.
Edison Electric Illuminating Co., Birmingham, Ala.
Boone Electric Light Co., Boone, Iowa.
Edison Electric Illuminating Co., Boston, Mass.
Edison Electric Illuminating Co., Brockton, Mass.
Edison Electric Illuminating Co., Brooklyn, N. Y.
Chester Electric Light & Power Co., Chester, Pa.
Chicago Edison Co., Chicago, Ills.
1st Cincinnati Edison Electric Illuminating Co., Cincinnati, O.
Canton Electric Light & Power Co., Canton, O.
Columbus Edison Electric Light Co., Columbus, O.
Edison Electric Illuminating Co., Cumberland, Md.
Dayton Electric Light Co., Dayton, O.
Des Moines Electric Co., Des Moines, Iowa.
Edison Electric Illuminating Co., Detroit, Mich.
Elgin Edison Light Co., Elgin, Ills.
Edison Electric Illuminating Co., Easton, Pa.
Edison Electric Illuminating Co., Erie, Pa.
Edison Electric Illuminating Co., Fall River, Mass.
Grand Rapids Electric Light Co., Grand Rapids, Mich.
Harrisburg Electric Light Co., Harrisburg, Pa.
Edison Electric Illuminating Co., Hazelton, Pa.
Edison Light Co., Jackson, Mich.
Johnstown Electric Light Co., Johnstown, Pa.
Edison Electric Light & Power Co., Kansas City, Mo.
Edison Light & Power Co., Lacrosse, Wis.
Edison Electric Illuminating Co., Lancaster, Pa.
Laramie Electric, Gas Light & Fuel Co., Laramie, Wyoming Ter.
Edison Electric Illuminating Co., Lawrence, Mass.
McKeesport Light Co., McKeesport, Pa.
Edison Electric Illuminating Co., Milwaukee, Wis.

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Edison Electric Illuminating Co., Middletown, O.
Edison Electric Illuminating Co., Mt. Carmel, Pa.
Edison Light & Power Co., Minneapolis, Minn.
Edison Electric Illuminating Co., New Bedford, Mass.
Edison Electric Illuminating Co., New Brunswick, N. J.
Edison Electric Illuminating Co., Newburgh, N. Y.
Edison Electric Illuminating Co., New Orleans, La.
Edison Electric Illuminating Co., of New York.
Edison Electric Illuminating Co., Newport, R. I.
The Norristown Electric Light & Power Co.
Edison Electric Light Co., Philadelphia, Pa.
Piqua Edison Electric Illuminating Co., Piqua, O.
Edison Electric Illuminating Co., Paterson, N. J.
Edison Electric Illuminating Co., Pottsville, Pa.
Reading Electric Light & Power Co., Reading, Pa.
Edison Electric Illuminating Co., Renovo, Pa.
Edison Electric Illuminating Co., Rochester, N. Y.
Forest City Electric Light & Power Co., Rockford, Ills.
Edison Sault Light & Power Co., Sault Ste. Marie, Mich.
Scranton Illuminating Heat & Power Co., Scranton, Pa.
Edison Electric Illuminating Co., Shamokin, Pa.
Skowhegan Electric Light Co., Skowhegan, Me.
Edison Electric Illuminating Co., Spokane Falls, Wash. Ter.
Edison Electric Light & Power Co., St. Paul, Minn.
Edison Electric Illuminating Co., Sunbury, Pa.
Edison Electric Illuminating Co., Tamaqua, Pa.
Tiffin Edison Electric Illuminating Co., Tiffin, O.
Edison Electric Illuminating Co., Topeka, Kan.
United States Electric Lighting Co., Washington, D. C.
Edison Electric Illuminating Co., West Chester, Pa.
Wilkes-Barre Electric Light Co., Wilkes-Barre, Pa.
Edison Electric Illuminating Co., Williamsport, Pa.
Edison Electric Light Co., York, Pa.

INFORMATION AND ESTIMATES

— FOR —

Edison Incandescent Electric
Light Plants

— FOR —

MILLS, FACTORIES, HOTELS, STEAMSHIPS, &c., &c.

AS WELL AS

LAMPS, SOCKETS, CUT-OUTS, WIRE
AND ALL OTHER SUPPLIES

MAY BE OBTAINED FROM

United Edison Manufacturing Co.,

65 FIFTH AVENUE,

NEW YORK.

1 watts per candle and with No. 1 Base.

RAILWAY LAMPS.

LAMPS.	Price, Each.
16 C. P. 5-in Series Railway Lamps	$0.85

1891

SPECIAL LAMPS.

Lamps.	Price.
16 Candle Power, Spiral	$1.25
32 " " "	2.20
50 " " "	4.00
100 " " "	5.50
150 " " "	6.50
Spiral Night Lamps,	1.50

The above Special Lamps are supplied from 97 to 125 Volts inclusive. Prices for lamps of other voltages supplied upon application.

Special Series Lamps, Marked for Amperes.—In ordering state Candle Power and Amperes required; also total Voltage of Circuit and Number of Lamps to be burned in one series. For List Price of Special Series Lamps add 20 per cent. to list of same candle-power Standard Lamps. About 30 days will be required in which to fill orders for Special Series Lamps.

Pressure Indicator Lamps.—Price, $2.40. Subject to discount of 45 per cent. in any quantity. In ordering, always give Indicator number.

MUNICIPAL LAMPS.

Lamps.	Price.
15 Candle Power, 2.7 to 3.3 Amperes	$1.25
20 " " 2.7 to 3.3 "	1.25
25 " " 2.7 to 3.3 "	1.25
30 " " 2.7 to 3.3 "	1.50
50 " " 2.7 to 3.3 "	2.50
100 " " 2.7 to 3.3 "	3.75

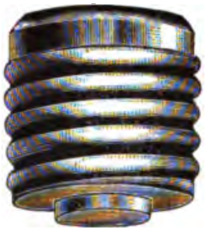
Municipal Lamps run approximately 1 Volt per Candle.

Special Price-List of Miniature Lamps furnished on application.

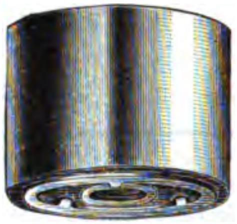
LAMP BASES.

Unless otherwise specified, all lamps will be shipped with No. 1 bases. The other bases, Nos. 2, 3 or 4, will be placed on lamps, when so ordered, without extra charge.

Lamps equipped with bases other than the Standard ones, as indicated below, will be supplied at prices depending on base required. Quotations on such lamps furnished on application.



No. 1.



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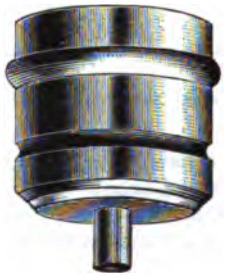
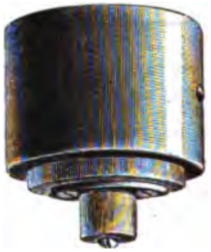


No. 3.



No. 4.

No. 1 is the Standard Edison Base.
No. 2 is the Thomson-Houston or Old Sawyer-Man.
No. 3 is the Westinghouse or New Sawyer-Man.
No. 4 is the United States.

Standard Packages for Lamp Shipments.

Edison Lamps will be shipped without any charge except for the Lamps themselves, in the following standard packages:

Package.	Contains 10, 16, 20 & 24 C. P.	Contains 32-50 C. P. & Mun.	Contains 100 C. P.
No. 1, —	150 Lamps,	75 Lamps,	15 Lamps.
No. 2, —	200 "	100 "	20 "
No. 3, —	1000 "	500 "	100 "

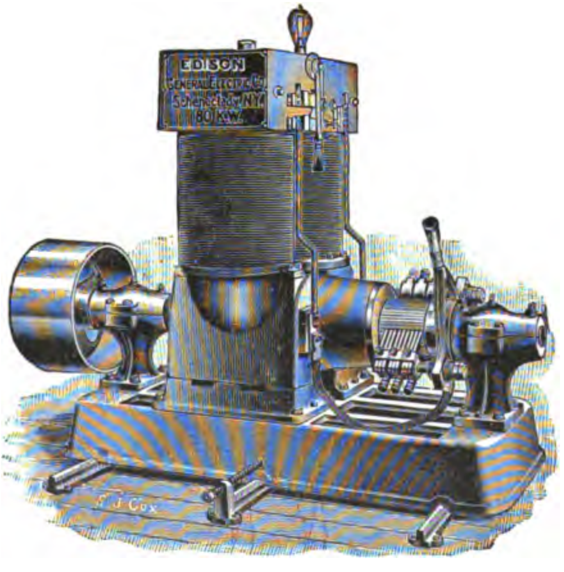
All shipments of quantities other than those contained in the above standard packages, will be charged for at the rate of 35 cents per package in addition to the price of the Lamps.

I. D. 121.
5-91-1000.

The Edison System of Central Station Lighting.

BRIEF INSTRUCTIONS FOR OPERATING

EDISON DYNAMOS


EDISON
GENERAL ELECTRIC Co.
Schenectady N.Y.
80 K.W.
F. J. Cox

IN CENTRAL STATIONS.

EDISON GENERAL ELECTRIC CO.,
Edison Building,
BROAD STREET, NEW YORK.

INTRODUCTION.

MANY writers and experimenters have given more or less elaborate description of dynamo-electric machines of various types, but from the numerous queries received by us from time to time, and the apparent lack of information pertaining to some special point on the part of station operatives, there seems to be a need of a brief line of instructions for parties operating Edison dynamos in central stations.

This deficiency in the literature of the dynamo is probably due to two causes: First, the comparative infancy of the business; and second, the rapidity of its growth has worked a limitation on the time of such practical men as could give pertinent information and direction on necessary points.

It is a source of regret that we have no precedent or previous practice to guide us, but that we are obliged to launch out somewhat boldly on a comparatively unknown field and set up our own signals and guide posts.

Many of us can easily call to mind the time, only some eight years back, when we knew nothing of the various peculiarities of the dynamo, its operation and manipulation was a mystery, and in the event of accident we had nothing to guide us, no person could tell us what to do, we had simply to work our way out as best we could; oftentimes the energies and patience were severely taxed, but thanks to this kind of experience we have had these things more deeply impressed upon us, and our knowledge is thus made more enduring.

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The dynamo of the present day is a far different machine from that of a few years ago, while its principles remain the same; the manufacturers have eliminated all the faults brought to their notice and perfected details of construction; the relative proportions and dispositions of the metals are vastly improved, so that to-day we can say the machine is eminently satisfactory, and is the most perfect and efficient machine in existence for the conversion of energy.

A book could easily be written on the subject of operating dynamos; this we do not intend to do; our pamphlet is simply designed to embrace such brief practical instructions as a person needs who is in daily care of dynamos, or is about undertaking such duties.

We desire to express our cordial thanks to all the gentlemen of practical experience in the Edison system who have so generously assisted in the preparation of these instructions.

THE DYNAMO IN THEORY.

IT is not proposed to elaborate in this pamphlet on the technical or mechanical construction of dynamos, but for the information of those who may not be fully informed and in order to bring out clearly a few fundamental features of the organization and construction of a dynamo, we take the liberty of making quotations from ***Lectures by Professor Sylvanus P. Thompson, before The Society of Arts, London.***

By "Dynamo-electric Machinery," in the most general etymological sense of the term, is meant machinery for converting the energy of mechanical motion into the energy of electric currents, or *vice versa.*

The name dynamo-electric machine appears to have been first employed by Dr. Werner Siemens, in his communication of January 17th, 1867, to the Berlin Academy, in which he described a machine for generating electric currents by the application of mechanical power, the currents being induced in the coils of a rotating armature by the action of electro-magnets, which were themselves excited by the currents so generated.

A dynamo-electric machine is a machine for converting energy in the form of mechanical power into energy in the form of electric currents, by the operation of setting conductors (usually in the form of coils of copper wire) to rotate in a magnetic field.

Faraday's Discovery.

ALL dynamos are based upon the discovery made by Faraday in 1831, that electric currents are generated in conductors by moving them in magnetic field. Faraday's principle may be enunciated as follows :

When a conductor is moved in a field of magnetic force in any way so as to cut the lines of force, there is an electromotive force produced in the conductor, in a direction at right angles to the direction of the motion, and at right angles also to the direction of the lines of force, and to the right of the lines of force, as viewed from the point from which the motion originates.

This induced electro-motive force is, as Faraday showed, proportional to the number of lines of magnetic force cut per second ; and is, therefore, proportional to the intensity of the magnetic "field," and to the length and velocity of the moving conductor.

To set up and maintain such electric currents uses up a continuous expenditure of energy, or, in other words, consumes power.

To induce currents in a conductor there must be relative motion between conductor and magnet of such a kind as to alter the number of lines of force embraced in the circuit.

Increase in the number of lines of force embraced by the circuit produces a current in the opposite sense to decrease.

The more powerful the magnet pole or magnetic field, the stronger will be the current generated (other things being equal).

The more rapid the motion, the stronger will be the currents.

The greater the length of the moving conductor thus employed in cutting lines of force (*i. e.*, the longer the bars, or the more numerous the turns of the coil) the stronger will be the currents generated.

The shorter the length of those parts of the conductor not so employed, the stronger will be the current.

Approach being a finite process, the method of approach and recession (of a coil towards and from a magnet pole) must necessarily yield currents alternating in direction.

By using a suitable commutator, all the currents, direct or inverse, produced during recession or approach, can be turned into the same direction in the wire that goes to supply currents to the external circuits, thereby yielding an almost uniform current.

Field Magnets.

IN a circuit where the flow of current is steady, it makes no difference what kind of magnets are used to procure the requisite magnetic field, whether permanent steel magnets or electro-magnets, self-excited or otherwise.

Hence the current of the generator may be itself utilized to excite the magnetism of the field magnets by being caused, wholly or partially, to flow round the field magnet coils.

Suppose then, it were determined to construct a dynamo upon any one of these plans—say the first—a very slight acquaintance with Faraday's principle and its corollaries would suggest that, to obtain powerful electric currents, the machine must be constructed upon the following guiding lines :

The field magnets should be as strong as possible, and their poles as near together as possible.

The armature should have the greatest possible length of wire upon its coils.

The wire of the armature coils should be as thick as possible, so as to offer little resistance.

A very powerful steam engine should be used to turn the armature, because,

The speed of rotation should be as great as possible.

As mechanical considerations forbid too high a velocity in the moving parts, it is clear that, if there be a limiting speed at which it is safe to run any given armature the greatest amount of work will be done at that speed by using the most powerful magnets possible, namely, electro-magnets rather than permanent magnets of steel.

The coils of the field magnets of a dynamo cannot be constructed of no resistance. They, therefore, always waste some of the energy of the currents in heat.

But if we do not get our magnetism for nothing, and find it more convenient to spend part of our current upon the electro-magnets, economy dictates that we should so construct them that their magnetism may cost us as little as possible. To magnetize a piece of iron requires the expenditure of energy ; but when once it is magnetized, it requires no further expenditure of energy (save the slight loss by heating in the coils, which may be reduced by making the resistance of the coils as little as possible) to keep it so magnetized, provided the magnet is doing no work.

When once established, the current is perfectly steady, and none of its energy is wasted on the magnet (save the negligible trifle due to the resistance of the coils).

Armatures.

THEORY dictates that if iron is employed in armatures, it must be slit or laminated, so as to prevent the generation of Foucault currents.

Cores built up of varnished iron wire, or of thin disks of sheet iron separated by varnish, asbestos paper, or mica, partially realize the required condition.

Armature cores should be so arranged that the direction of polarity of their magnetization is never abruptly reversed during their rotation. If this precaution is neglected, the cores will be heated.

All needless resistance should be avoided in armature coils, as hurtful to the efficiency of the machine. The wire should therefore be as short and as thick as is consistent with obtaining the requisite electro-motive force, without requiring an undue speed of driving.

The wire should be of the very best electric conductivity

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The conductivity of good copper is so nearly equal to that of silver (over 98 per cent.), that it is not worth while to use silver wires in the armature coils of dynamos.

Since it is impossible to reduce the resistance of the armature coils to zero, it is impossible to prevent heat being developed in those coils during their rotation.

The insulation of the armature coils should be ensured with particular care, and should be carried out as far as possible with suitable materials not liable to be melted if the armature coils become heated.

Commutators.

Commutators and collectors being liable to be heated through imperfect contact, and liable to be corroded by sparking should be made of very substantial pieces of copper.

In the case of a collector made of parallel bars of copper, ranged upon the periphery of a cylinder, the separate bars should be capable of being removable singly, to admit of repairs and examination.

The brushes should touch the commutator or collector at two points, in a properly and symmetrically built dynamo. These points will be at opposite ends of a diameter.

The Neutral Point.

IN consequence of the armature itself, when traversed by the currents, acting as a magnet, the magnetic lines of force of the field will not run straight across, from pole to pole of the field magnets, but will take, on the whole, an angular position, being twisted a considerable number of degrees in the direction of the rotation. Hence the diameter of commutation (which is at right angles to the resultant lines of force in machines of the Siemens and Gramme type, and parallel to the resultant lines of force in machines of the Brush type), will be shifted forward. In other words, the brushes will have a certain angular lead. The amount of this lead depends upon the relation between the intensity of the magnetic field and the strength of the current in the armature.

Hence in all dynamos it is advisable to have an adjustment, enabling the brushes to be rotated round the commutator or collector, to the position of the diameter of commutation for the time being. Otherwise there will be sparking at the brushes, and in part of the coils, at least, the current will be wasting itself by running against an opposing electromotive force.

Efficiency.

THE efficiency of a dynamo-electric machine is the ratio of the useful electrical work done by the machine to the total mechanical work applied in driving it. Every circumstance which contributes to wasting the energy of the current reduces the efficiency of the machine.

Mechanical friction of the moving parts can be minimized also by due mechanical arrangements. But electrical loss cannot be entirely obviated. because even the best conductors employed have a certain resistance.

It only remains to develop certain theoretical considerations respecting the method of exciting the magnetism of the field in which the armatures are to revolve.

Shunt Dynamos.

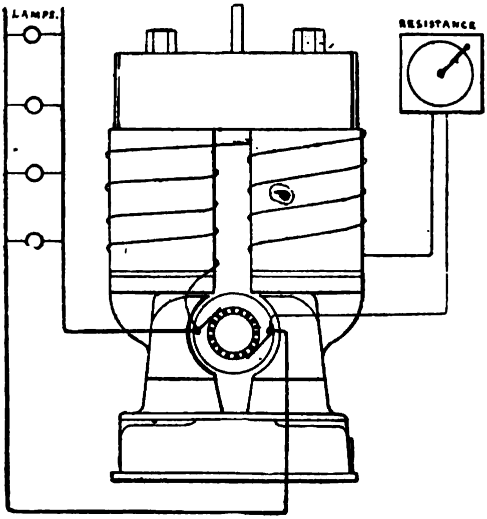


Fig. 1.

THE shunt dynamo (Fig. 1) has several advantages over other forms. It is less liable to reverse its polarity than the series dynamo, and it is commonly considered as providing the magnetizing power to the magnets with less waste of current.

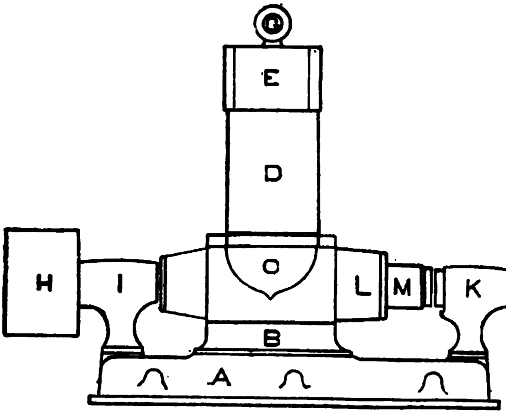
Moreover, for a set of lamps in series, its power to supply the needful current increases with the demands of the circuit, since any added resistance sends additional current round the shunt in which the field magnets are placed, and so makes the magnetic field more intense. On the other hand, there is a greater sensitiveness to inequalities of driving in consequence of the great self-induction in the shunt.

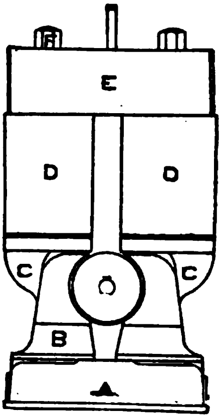
Now, as the first function of a dynamo in practice is to feed with sufficiency and regularity a system of lamps, and as those lamps are always in practice arranged either in series or in parallel, it is clear that in the former case a constant current, and in the latter a constant electro-motive force, is required.

If the shunt coils be comparatively few and of high resistance, so that their magnetizing power is small, the machine will give approximately a uniform electro-motive force.

All these arrangements presuppose a constant velocity of driving, but they are not the only ones consistent with this condition.

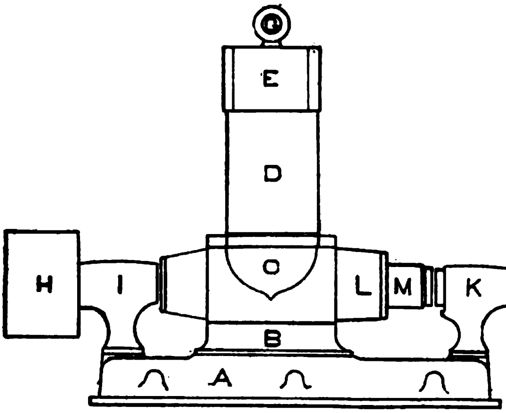
A shunt dynamo may be controlled so as to yield a uniform electro-motive force by introducing a variable resistance into the shunt-magnet circuit as is done in Edison dynamos.

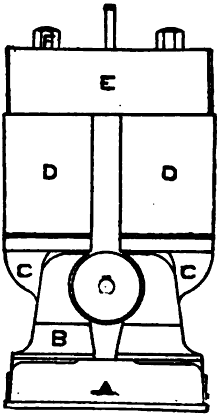




A Base Plate
B Zinc Field Bases
C Field Pieces
D Magnet Cores
E Keeper
F Keeper Bolts
G Eye Bolt
H Pulley
I Pillow Block (Pulley end)
K Pillow Block (Commutator end)
L Armature
M Commutator

Dynamo No.	Amperes.	Volts.	Kilo Watts.	Speed.	Pulley.		Principal Dimensions.			Weight.		Resistance.	
					Diameter.	Width.	Length.	Width.	Height.	Net.	Gross.	Magnets.	Armature
				Rev. per Min.	Inch.	Inch.	Inch	Inch.	Inch.	Lbs.	Lbs.	Ohms.	Ohms.
1	20	125	2.5	1900	$7\frac{1}{2}$	3	33	$28\frac{3}{16}$	$31\frac{1}{8}$	550	655	110	.331
2	40	125	5	1800	8	4	$38\frac{5}{8}$	$32\frac{1}{8}$	$35\frac{1}{8}$	830	1035	54.4	.116
3	60	125	7.5	1700	$8\frac{1}{2}$	5	$44\frac{1}{8}$	33	$38\frac{5}{8}$	1090	1320	43.6	.068
4	80	125	10	1600	9	6	$48\frac{3}{8}$	$33\frac{1}{4}$	$42\frac{5}{8}$	1470	1765	52.	.0425
6	120	125	15	1500	$11\frac{1}{4}$	8	57	48	$46\frac{7}{8}$	2130	2565	44.6	.032
8	160	125	20	1400	12	9	$65\frac{13}{16}$	$50\frac{3}{4}$	$50\frac{7}{8}$	2880	3075	22.	.02
10	200	125	25	1300	13	10	$68\frac{5}{16}$	$52\frac{1}{4}$	54	3570	3970	37.	.0167
12	240	125	30	1200	14	11	$73\frac{1}{2}$	$54\frac{1}{8}$	$56\frac{3}{4}$	4340	4810	30.	.0108
16	320	125	40	1000	17	12	$83\frac{9}{16}$	58	$66\frac{1}{2}$	6800	7770	22.6	.009
20	400	125	50	700	24	13	$92\frac{1}{2}$	$62\frac{5}{8}$	75	9790	10590	21.2	.009
32	575	140	80	650	26	16	$105\frac{1}{16}$	$68\frac{3}{8}$	$82\frac{1}{2}$	16200	17500	16.4	.00515
60	1075	140	150	450	44	21	$118\frac{5}{8}$	$89\frac{1}{2}$	103	31790	34700	6.38	.00252



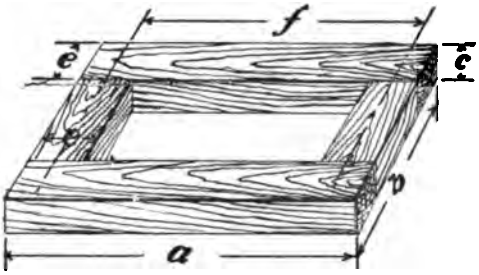


A Base Plate
B Zinc Field Bases
C Field Pieces
D Magnet Cores
E Keeper
F Keeper Bolts

G Eye Bolt
H Pulley
I Pillow Block (Pulley end)
K Pillow Block (Commutator end)
L Armature
M Commutator

					PULLEY.		PRINCIPAL DIMENSIONS.			WEIGHT.		RESISTANCE.	
Dynamo No.	Amperes.	Volts.	Kilo Watts.	Speed.	Diameter	Width.	Length.	Width.	Height.	Net.	Gross.	Magnets.	Armature
				Rev. per Min.	Inch.	Inch.	Inch.	Inch.	Inch.	Lbs.	Lbs.	Ohms.	Ohms.
1	20	125	2.5	1900	7½	3	33	28 3/16	31⅛	550	655	110	.331
2	40	125	5	1800	8	4	38⅝	32⅛	35⅛	830	1035	54.4	.116
3	60	125	7.5	1700	8½	5	44⅛	33	38⅝	1090	1320	43.6	.068
4	80	125	10	1600	9	6	48⅜	33¼	42⅝	1470	1765	52.	.0425
6	120	125	15	1500	11¼	8	57	48	46⅞	2130	2565	44.6	.032
8	160	125	20	1400	12	9	65 13/16	50¾	50⅞	2880	3075	22.	.02
10	200	125	25	1300	13	10	68 5/16	52¼	54	3570	3970	37.	.0167
12	240	125	30	1200	14	11	73½	54⅛	56¾	4340	4810	30.	.0108
16	320	125	40	1000	17	12	83 9/16	58	66½	6800	7770	22.6	.009
20	400	125	50	700	24	13	92½	62⅝	75	9790	10590	21.2	.009
32	575	140	80	650	26	16	105 1/16	68⅜	82½	16200	17500	16.4	.00515
60	1075	140	150	450	44	21	118⅝	89½	103	31790	34700	6.38	.00252

TABLE SHOWING DIMENSIONS OF DYNAMO BASE FRAMES.



	Type of Dynamo	A	B	C	D	E	F
Without Centre Pieces.	1	26	25	3½		6	20
	2	30	30	3½		6	24
	3	34¼	30¾	3½		6	28¼
	4	32¼	31¾	3½		6	26¼
	6	40½	37¼	6		8	32½
	8	47	40	6		8	39
	10	46	42	6		8	38
	12	50½	48½	6		8	42½
With Centre Pieces.	16	62	50	6	27	8	54
	20	72	54	8	30	12	60
	32	82	64	8	35	12	70
	60	91½	78½	8	39¾	12	79½

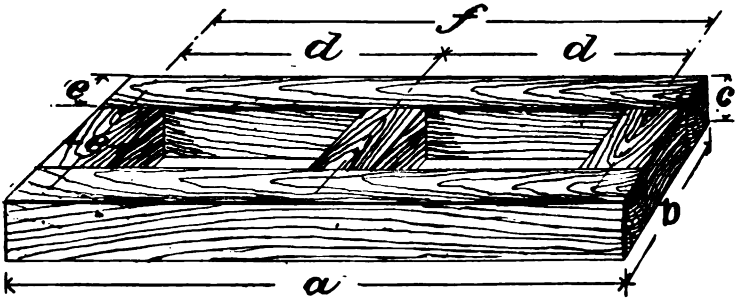
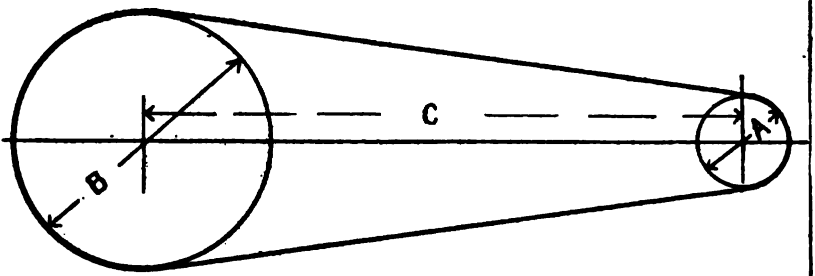


TABLE SHOWING RELATIVE DIAMETERS OF DYNAMO PULLEYS, AND ENGINE PULLYS, REVOLUTIONS PER MINUTE, AND MINIMUM DISTANCE BETWEEN CENTERS.



DYNAMOS.			ENGINES.		MINIMUM DISTANCE BETWEEN CENTRES.
No.	PULLEY.		PULLEY.		
	Diam. A.	Rev.	Diam. B.	Rev.	C.
6	11¼″	1500	52″	325	12½″
8	12″	1400	60″	282	13″
10	13″	1300	60″	282	14″
12	14″	1200	60″	282	14″
16	17″	1000	66″	260	15″
20	24″	700	66″	260	15″
32	26″	650	86″	200	16″
60	43″	450	86″	225	16″

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LOCATION, SETTING AND STARTING OF DYNAMOS.

THE dynamo should be located in a clean, dry place, and preferably in a room of low temperature.

The foundations should be of a substantial character, solid mason work or stout framing, sufficient to obviate all vibration while the machine is in operation.

The proper insulation of the dynamo from "earth" is vital. To secure this a stout frame of heavy timber is provided; this is secured to the foundation. The frame should be thoroughly treated with some moisture repellant, such as asphalt varnish.

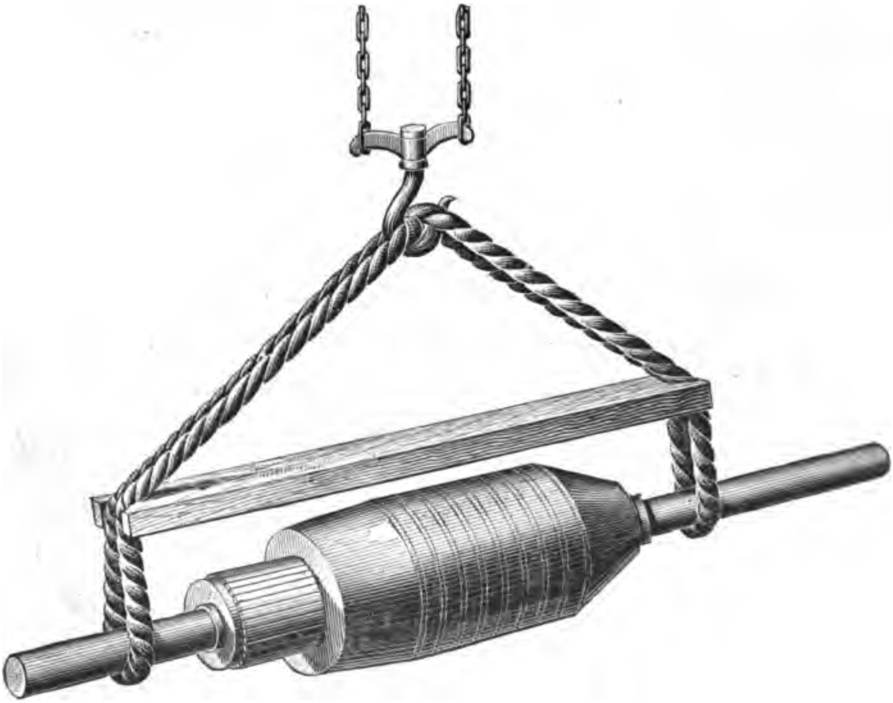
The base frame should be so treated when thoroughly warm and dry.

To provide for and take up the stretch of belts, the distance between centres of engine and dynamo shaft must be increased; some dynamos are mounted upon rails or tracks, grooves in the base frame of the dynamo fitting the track. The slack belt is taken up by moving the machine over with the tightening screws.

In large stations where the dynamos are located upon a floor above the engines a lifting device is now provided by which a heavy machine can be raised, thus taking up the slack belt.

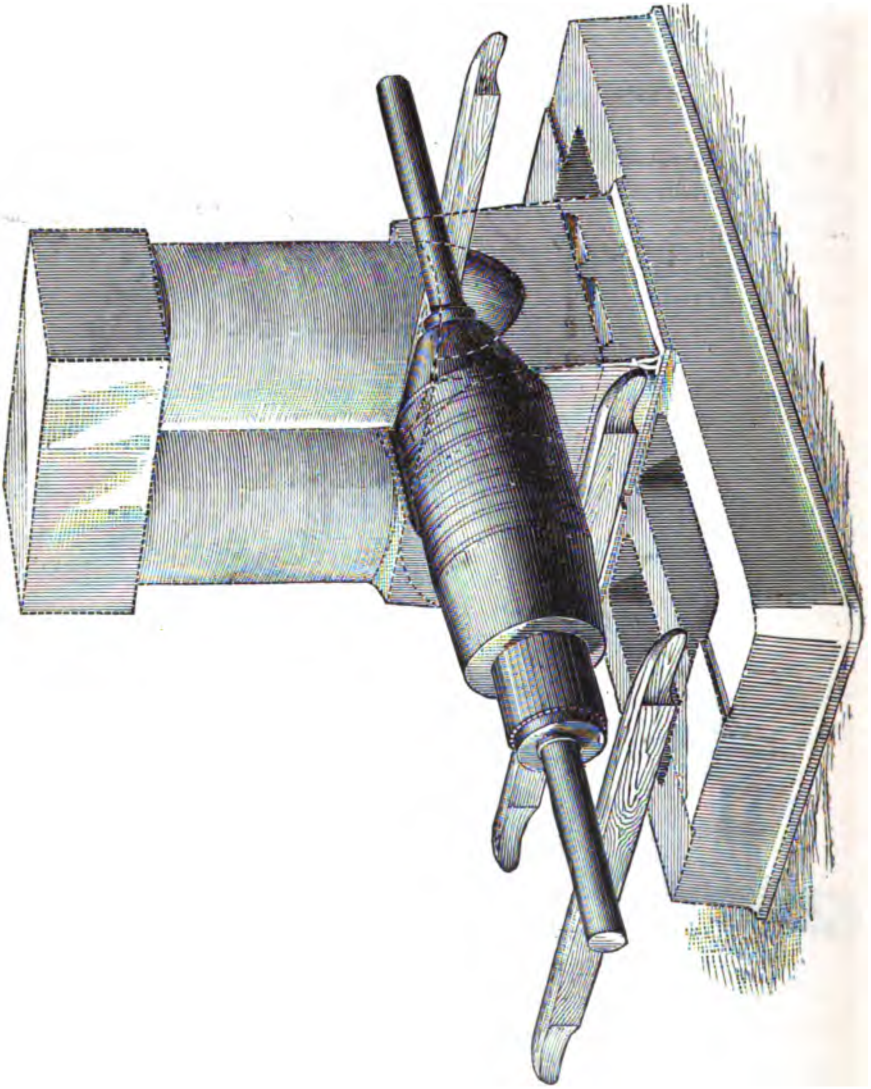
Directions for Handling Armatures.

In setting up dynamos it is very important that the armature and field cores be carefully handled so as to avoid abrasion of the insulation of exterior or interior parts.



METHOD OF SWINGING ARMATURE.

Plan Showing Method of Getting Armature Out of Field or Replacing Same.



EXERCISE *great care* in handling.

USE only *Rope* sling and *Wooden* bars.

HANDLE as much as possible by the shaft.

ARMATURE.	WEIGHT.	
	NET.	GROSS.
1	60 lbs.	100 lbs.
2	100 "	150 "
3	125 "	175 "
4	160 "	215 "
6	220 "	300 "
8	320 "	390 "
10	410 "	620 "
12	530 "	725 "
16	805 "	1050 "
20	1070 "	1450 "
32	2155 "	2525 "
60	4880 "	5400 "

When it is necessary to lift on the body of the armature, be extra careful; take hold *only* where the bands around the body are, never on the canvas heads; use a pad of felt or cotton waste between the bar and the armatage body.

Never under any circumstances or in any manner make use of the commutator in handling the armature.

Do *not* allow the weight of the armature to rest on it for a moment.

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Do *not* touch it with the bars or slings.

Never lay armature down unless you have a thick. soft pad between it and the floor.

All pieces are marked so as to indicate where they match with other parts. *All surfaces should be perfectly cleaned and free from dust or dirt.*

This is *specially important* as pertaining to the large surfaces where the magnet cores are bolted to the yoke and field blocks. *Imperfect surface contact will reduce the strength of the magnets.*

The dynamo should be carefully leveled up, and its pulley and shaft accurately lined with the shaft and pulley of the driving power. Satisfactory operation of the belt depends largely upon careful work in setting the machine.

Special care must be observed to have the pillow blocks carefully adjusted, the surfaces clean and well oiled, both on shaft and bearing, before fitting together.

It is quite important that before a new dynamo is put at steady work it should be run a few hours first at slow speed, which may be gradually increased to the maximum. During this trial run without current, carefully attend to the bearings, correct any tendency to heating by a liberal supply of oil, and scraping the Babbitt shells if necessary to secure perfect bearing surface. Make sure that all these things are in perfect condition previous to putting the dynamo at work on the circuit.

After getting a new dynamo ready to run, having made all the electrical connections (excepting between it and the 'Bus line), start it up, charge field, and make it generate sufficient current to light its pilot lamp. This will assure you that you actually have it in proper condition for producing current. Having satisfied yourself on this point the connection can be made to 'Bus line.

NOTE.—See special instructions on starting new self-oiling bearings.

Cleanliness about the Dynamo is Essential.

ALL parts of the dynamo should be kept neat and clean. Dirt, copper dust and oil should not under any circumstances be allowed to gather on any part, especially in crevices near those parts which are carrying current.

Copper dust in even small particles may be a source of much annoyance. It is very detrimental to the dynamo, and will seriously imperil the durability of the insulation on magnets and armature.

Oil cans, tools, bolts and pieces of iron should be kept away from the dynamo, as they are liable to be drawn into the field and injure the armature.

A good rule is, ***never allow a loose article of any kind to be placed upon any portion of a dynamo.***

They are not only liable to be drawn in, but to fail upon the armature or commutator.

Brass or copper oil cans are best to use, as they are non-magnetizable.

Switches, Connections and Contacts.

A LARGE, clean surface contact is important.

The contact surfaces of switches and all connections should be sufficiently firm to secure good conductivity, and be kept clean and bright. All connecting screws should be set firmly and securely down.

When the dynamo is not in operation leave the switch open. All contacts and connections should be frequently inspected while dynamo is in operation to see that there is no undue heating, and should be gone over thoroughly at intervals to detect any loose or insecure connections.

NOTE.—See diagrams and instructions for connecting under chapter on *testing*.

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Speed.

IN order to produce the most satisfactory results the dynamo must be run at its normal speed.

The highest efficiency of the dynamo is obtained only when running at its proper speed. If the speed falls off, the magnetic field must be made stronger in order to keep the pressure up, and a largely increased amount of current is required to secure a small increase of strength in the magnetic field. The result is that the efficiency diminishes.

Oil.

THE high speed at which the dynamo runs requires a lubricant especially adapted for such speeds. Uniformity of rotation and absolute reliability are of first importance.

The value of an oil depends more upon its power to reduce friction and prevent the excessive development of heat, than upon its market price. Cheapness can never compensate for inferior quality.

The characteristics which should be possessed by the oil in order to be most efficient as a lubricant for dynamos, are:

1. Sufficient density or body to keep the surfaces, between which it is interposed, from coming in contact under greatest pressure.

2. The greatest adhesion to metallic surfaces, and the least cohesion in its own particles, are qualities of the best oils, and in this respect fine mineral oils stand first.

3. The fluidity of the oil should be as much as is consistent with the above conditions.

We have found the *Vacuum oil* and *Eldorado engine oil* to be possessed of all these necessary qualities and recommend either of them for use on Edison Dynamos.

Keep your oil free from gritty matter. All foreign matter injures the quality of the oil, and tends to increase the heat of bearings.

New oil should *always* be filtered.

Economy in the use of oil depends largely upon the methods of applying it. By the use of oil cups with adjustable feed a perfectly uniform supply of the minimum safe quantity can be applied to the journal.

Careful experiment will show many drops of oil per minute are required for proper lubrication.

Oil, after passing through the journal, is drawn off from the interior of the pillow block. If of good quality, it has not deteriorated, and may be filtered and used over again.

Do not Fail to Keep the Bearings in Good Condition.

ATTENTION must be given to the oil cups and bearings of the dynamo while running. The supply of oil should be constant and of the minimum amount required for perfect lubrication.

Watch the bearings on a new dynamo very closely for a few days and use oil liberally.

After a new dynamo has been operated a few days, all bearings should be made to work at a normally low temperature.

Under proper conditions no reasonable excuse can be offered or accepted for abnormal heating. If it exists, it needs immediate investigation and remedy.

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After being in operation a short time, a certain amount of heat is imparted to the bearings by the armature—any undue heating aside from this requires an immediate remedy by the attendant.

The temperature may reach blood heat when running with full load. The commutator bearing may be expected to become slightly warmer than the pulley bearing.

Undue heating may result from a variety of causes. Among these may be mentioned insufficient quantity or poor quality of oil, dirt or gritty matter in oil, a badly scraped bearing, rough journal, boxes too tight, belt too tight, an armature shaft slightly bent, bearings out of line, or dynamo overloaded.

If from any cause a bearing becomes unduly warm, a liberal supply of oil may be sufficient to check the heat. If it gets very hot the cap screws should be slightly loosened, the oil cup removed, and oil, cooled in water, plentifully applied. It is not advisable, however, to use water on the interior of the bearing unless sure that it is free from dirt or gritty particles.

The cause of the heating should always be ascertained and remedied, and the boxes removed, cleaned, scraped and accurately refitted before starting up again.

After removing a pillow block be scrupulously careful in replacing to see that contact surfaces and steady pins are free from grit, fibres of waste, or any kind of dirt.

If the ***bearings*** should become ***considerably worn, there is danger that the armature may rub*** on the bottom or side of the field blocks, and loosen the binding wires, which is sure to ruin the armature. By observing the position of the armature in the field, it may readily be seen whether the bearings are worn down to any considerable extent.

A small amount of wear downwards may be remedied by raising the pillow blocks with a piece of cardboard or sheet iron. If they are badly worn, or worn sideways, the bearings should be rebabbitted.

Bearings Out of Line may be Due to:

1. An uneven foundation causing a distortion of dynamo base;
2. Or improper setting and bolting of the pillow blocks;
3. Or improper fitting in place of the babbitt shells.

Boxes too Tight.

This can be remedied by loosening up on the nuts holding down cap of pillow block; a layer of cardboard of proper thickness may be inserted on the joint under cap and the nuts screwed down.

Belts Too Tight.

CAUSES.

1. Abnormally short belt.
2. Belt of insufficient width.
3. Belt of poor quality or lacking in thickness.

The pulleys on all dynamos have been carefully proportioned so that when belts are applied according to specifications, the full load can be pulled without trouble.

Bent Armature Shaft.

This is a rare occurrence, and can be remedied by a competent machinist.

A sprung shaft should be straightened very carefully in a lathe. In springing it true a pad of cloth or waste and a block rounded to fit armature body should be used between the end of pry and the armature. ***This is an operation requiring care, as the insulation is liable to be jammed.***

Overloaded Dynamo.

This would cause excessive strain on belt and a necessary tightening thereof; also, an abnormal heating of armature, and the increased internal heat conducted to bearings.

Self-oiling Bearings.

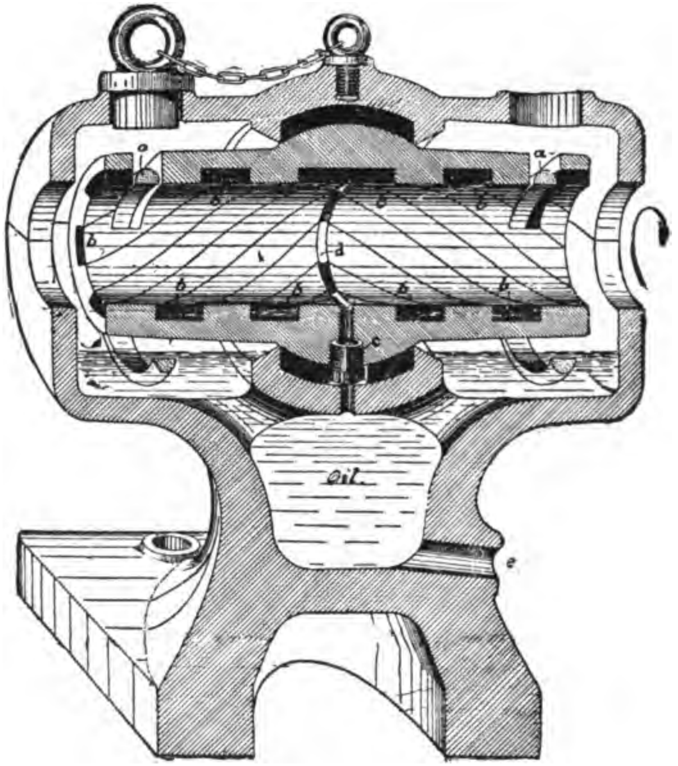

Fig. 3.

A new self-oiling bearing for dynamos has been devised which aims to secure absolute reliability against heating, as well as perfect and economical lubrication.

Little attention is required, and there is much less danger of undue heating than with the ordinary bearing.

They can he fitted to existing dynamos in place of the old bearing, and are great savers of oil.

With the construction shown in cut, the revolving rings "*a*" carry from the reservoir to both ends of the sleeve a continual supply of oil which is swept, by the action of the revolving shaft, on the spirals "*b*" towards the centre of the bearing, where it is collected by the central groove "*d*" and returned by the hole "*c*" to the reservoir, where it has time to settle and cool.

By these means a continual circulation of oil through the bearing is automatically started, kept up and stopped by the motion of the shaft, the bearings requiring no attention beyond a periodical examination and, when necessary, renewal of the oil, which may be drawn off from the reservoir by a pet cock tapped at "*e*".

This bearing will only act for running in one direction; for the bearing in the sketch the arrow shows the direction of rotation. To run the shaft the other way the sleeve would have to be turned end for end. It is, therefore, IMPERATIVE that the bearings be correctly put together. For this purpose an arrow is stamped on the upper surface of the ball bearing of the sleeve, and the latter must be set so that looking down on the bearing the upper surface of the shaft runs in the direction that the arrow points.

The bearings should be examined once a week, although the oil does not require renewal as often as that.

Note.

Extra care and attention must be given to *starting* a new dynamo with self-oiling bearing, or in *first use* of these new bearings on an old dynamo. Watch them carefully and give frequent attention until you are sure no undue heating will be developed.

CHARGING AND TESTING.

AT the manufactory the Edison dynamos are wound, charged and connected in such a manner that the positive (+) current will always be derived from the under brush.

Any change in the direction of rotation of the armature is compensated for by alteration of the magnet connections on the switch board. A dynamo having been once magnetized should always thereafter retain sufficient residual magnetism to charge itself. If through accident or otherwise it should become demagnetized, it may be again charged by current from another dynamo or a gravity or bi-chromate battery.

In charging dynamos with a battery the copper or carbon plate is to be applied to the + terminal of the field. One cell of storage battery, two of bichromate or Bunsen, or six of gravity or Le Clanché should be used. The dynamo current is more satisfactory. To determine the positive + pole in the case of the dynamo current, use the ordinary test paper or put both ends of the wire into a glass of water, carefully avoiding contact. Both wires will give off bubbles of gas, but the positive + much LESS than the negative —.

In charging the magnets the positive pole of the battery is connected to the terminal of the inside wire of the right-hand coil, facing the switch-board, and the negative pole to the left-hand coil. This will make the right-hand pole a south pole, and the left-hand pole a north pole.

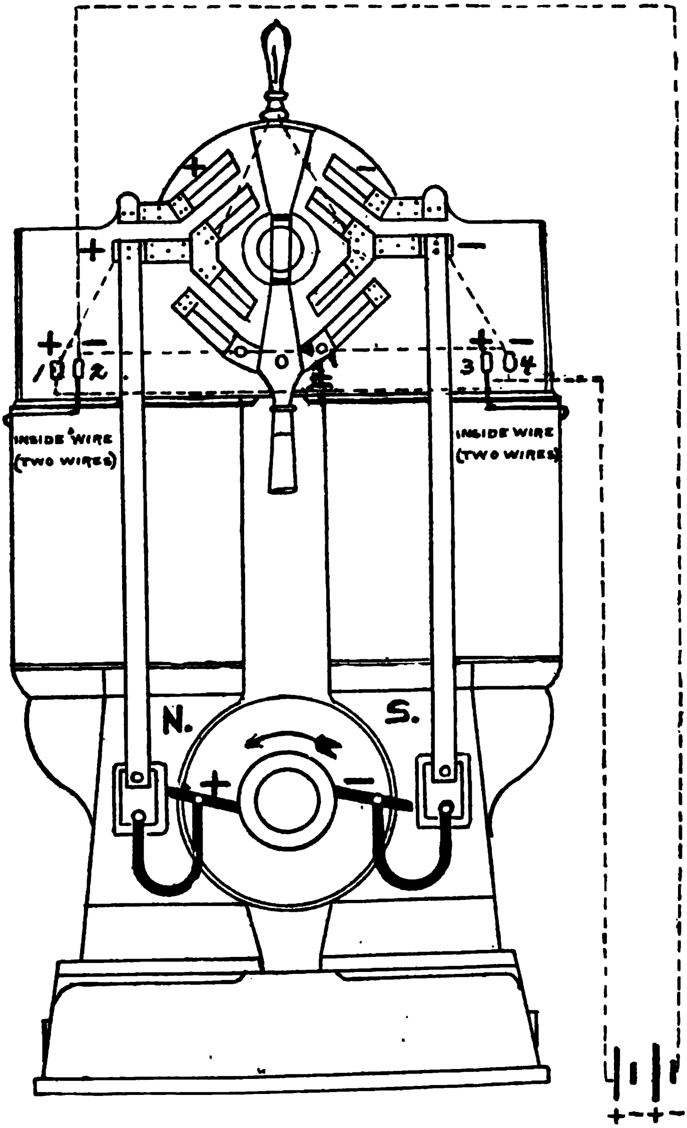

FIG. 4.

In the central station dynamo there are four binding posts for the field lines, as shown in the above figure, No. 1, No. 2, No. 3, No. 4, two at each end of the switch-board.

The inside terminal of each coil is brought to one or another of these posts according to the direction of rotation.

If the armature revolves from right to left, as in Fig. 4, the terminals of the magnet must be connected to the inside posts No. 2 and No. 3. The left or under brush will then be positive, and the right or upper negative.

The left hand positive wire is connected behind the switchboard to posts No. 3 and No. 1, the right hand wire negative to No. 2 and No. 4.

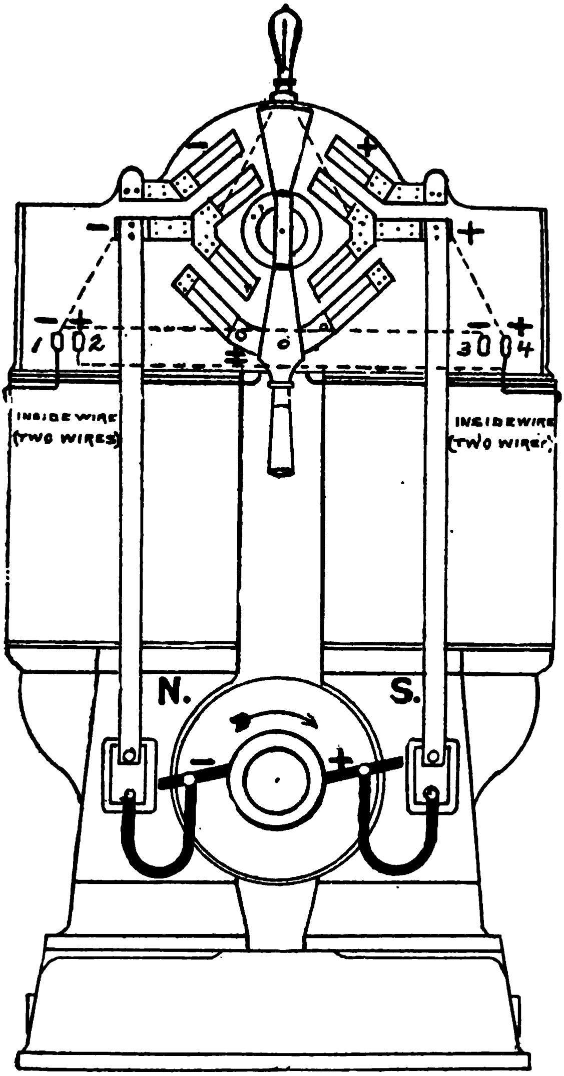

FIG. 5.

If the armature revolves from left to right, as in Fig. 5, the magnet terminals must be connected to the outside posts No. 1 and No. 4, The right or under brush will then be positive, and the left or upper brush negative.

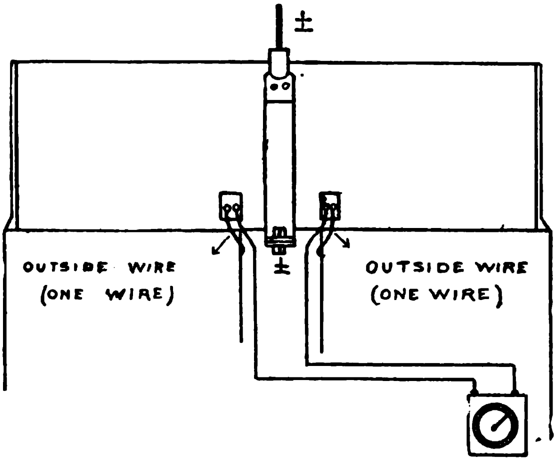

Fig. 6.

The two outside wires should he brought to connecting plates on back board of dynamo, to which the wires from the regulator are attached. See Fig. 6.

In both cases, when the magnets are charged, so that the right hand pole is the south pole, and the left hand the north pole, the under brush is positive.

The polarity of the coils should never be reversed.

If by any chance the polarity of the field magnets becomes reversed, the field connections remaining as above, the conditions described will be reversed.

The polarity of the wires is reversed either by reversing the polarity of the field magnets or the direction of rotation of the armature.

Reversing the polarity of a dynamo does not impair its efficiency.

TESTING FIELD AND ARMATURE.

THE dynamo must at intervals be disconnected from the circuit and thoroughly tested to make sure that the armature and field wires are free from leakage between the windings and the base. This test should be made at regular intervals with tangent Galvanometer and Rheostat, and a record kept of the readings.

If a galvanometer is not to be had use a magneto.

The insulation between the body of the dynamo and all parts of the circuit must be perfectly maintained. Avoid loose coils or loops in the field connections. If the insulation on the flexibles leading from brushes becomes worn after long use have it renewed.

A standard insulation of *one meg-ohm* should be maintained in armature and fields from base and of base from earth.

The faults which are liable to occur in both field magnets and armature coils are as follows :

1st. A cross between separate coils, or turns of a coil which are side by side, or cross each other.

When this occurs in magnets a portion of the coil is cut out, and its strength is diminished. A fault of this kind in the armature results in a loss of power, and possibly in burning out of the faulty coils.

A dynamo may still work with a large part of its field coils short circuited. Such a condition is shown by one magnet coil getting hotter than its mate.

Each coil of armature and each side of field magnet should be separately tested.

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If a magnet coil is grounded at two points the current is shunted around a portion of the coil, as in the first case.

If two armature coils of considerable difference of potential are grounded on the core, they will probably be burned out, and in any event will reduce the power of the dynamo.

In either case the fault may be detected by testing the insulation of the coil. Each coil of armature must be tested separately.

The insulation resistance of the whole armature to ground may be first taken. If defective, the coils must be partially disconnected from the commutator, and separately tested.

In stations operated less than twenty-four hours per day, a careful test should be made for crosses or grounds before steam is turned on.

This test should be made sufficiently early to insure the correction of the trouble (should any be found) before the hour of starting the station.

In starting, the dynamos connected with the system should be without pressure and gradually raised to proper E. M. F. ; this will develop any fault originating since making test, and before any damage is done to either the system or appatatus.

The positive and negative sides of the system should be prominently indicated on all the conductors and electrical apparatus in the station.

A good plan to follow is for positive, use letter "A" in red ; negative, use letter " B " in blue.

The electrical apparatus of the station should be so arranged that a *circuit switch* is provided for *each dynamo*.

This circuit switch should be used for throwing the dynamo in and out of circuit.

The *dynamo-changing switch* is mounted on the dynamo, and should only be used for changing the dynamo over from one side of the system to the other.

It should not be used for throwing the dynamo in and out of circuit.

Each side of the switch should be prominently lettered to indicate respectively the "A" and "B" sides of the system.

OPERATING A PAIR OF DYNAMOS IN SERIES.

BEFORE starting up a pair of dynamos, inspect thoroughly every part, and have brushes, switches and connections in perfect order.

The engine should be gradually warmed and started a short time before the dynamos are needed, and kept turning slowly. They are then in readiness for instant use when needed.

If this precaution is omitted, trouble is likely to result in the hurry and confusion of a sudden demand for light.

The Following Order of Procedure Should be Observed for Starting Up:

1. Fill oil cups and adjust feed.

2. Get full speed on engine and armatures of both dynamos. Be sure that all switches are open, belts properly tightened, and everything in perfect order.

3. Adjust the brushes to both commutators. They should rest on the commutator a little in advance of the extremities of a horizontal diameter, before throwing on the load.

4. Make sure that the fields of both dynamos are charged up properly. The strong attraction of a piece of iron will indicate that the field is made.

If a dynamo is thrown in multiple with other dynamos, before its field is charged, a short circuit will be formed through its armature, and it may be burnt out.

5. Throw in dynamo galvanometer on first dynamo, and regulate pressure to the proper electro-motive force.

One side of the dynamo galvanometer is connected to the neutral "Bus." The other side is connected to a switch, from which wires are to run to the neutral side of each dynamo, between the reversing switch and the brush. The galvanometer can be thrown on any dynamo. When the pressure of the dynamo is the same as that of the circuit in which it is to be thrown, no current flows through the galvanometer, and it stands at zero.

6. Close the dynamo circuit switch. Care must be taken that it is done quickly.

Adjust the brushes at once.

If a dynamo is at the same or nearly the same potential as system (say within 1½ volts), then there will be practically no change in ammeter or pressure indicator readings on closing the switch, nor will there be any spark on making or breaking contact. The brushes will not need to be adjusted until the field of the machine just thrown in has been slightly strengthened and the field or fields of the machine or machines previously running on that side have been weakened. Repeat this process, which should be a gradual one, until the load is equally divided between all machines on that side of the system. Then switch in the machine on the other side of the system, following the same process. It is better to finish with one side before going to the other.

As the load gradually changes the brushes may require adjustment to the non-sparking point.

A dynamo should never be thrown on the system until its pressure is exactly equal to that of the "Bus" circuit.

If a dynamo is thrown in multiple with other dynamos while its pressure is low the current in it would probably be reversed, and it would run as a motor. It would then take current from the system, and increase the load upon the other dynamos instead of helping to carry it.

Unequal Division of Load.

IN the case of a pair of dynamos in series on the three-wire system, the division of load will depend on the balancing of the lights on the system, as well as on the pressure between the two sides. If pressures are all right an unequal division would indicate an unbalanced condition of the system which should be at once corrected.

If a dynamo is in multiple with another it may, if its pressure is too high, assume a portion of the load of the second dynamo, or even drive it as a motor. Overloading of the dynamo and heating of the armature is the result.

The obvious remedy is to regulate the pressure at once from the resistance box.

Care must be taken that surplus resistance is not thrown into the field. Too much resistance will cause the current to rise again, indicating that it is reversed and the dynamo running as a motor.

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When throwing a dynamo out observe the pressures on the system, and adjust the regulators of the remaining dynamos to keep the pressure at the proper point, also adjust all brushes to the increased load. The loads on both dynamos should be worked down together, and the second dynamo cut out as soon as possible after the first.

Dynamos should never be switched out on full load, except in case of extreme emergency.

The brushes should not be raised until the lamp on the headboard ceases to show incandescence. If this point is neglected the discharge of the field magnet coils may break the lamp, jump to base of machine or cause other trouble.

Having thrown out both dynamos, raise the brushes and clean and polish the commutators (if necessary) before stopping the engine in order to have them in readiness for the next run.

Shut down the engines slowly, and stop the oil feed.

The dynamos should then be thoroughly cleaned of oil, dirt and copper dust, and put in perfect order for the next run.

The engine should never be slowed down before the circuit switches are thrown out. Failure to observe this rule may result in burning out armatures.

Make sure that the opened switches and lifted brushes are securely fixed in position against any chance of getting loose and unintentionally closing the circuit, which might result in serious damage.

In Shutting Down Final Pair of Dynamos.

In shutting down a system when only one pair of machines are running, shut down the engine and do not touch the resistance box. If this method be used there will be practically no sparking or adjustment of brushes required. Operate switches, and lift the brushes.

COMMUTATOR.

SPECIAL care and attention must be given to the commutator.

The perfect or imperfect condition of the commutator in a central station is strong evidence of the competency or incompetency of the attendants. There is a certain knack in caring for a commutator easily acquired by any careful and painstaking man.

Prevention, not cure, is the correct rule for commutator troubles. The life of a well cared for commutator should not be less than two years of CONTINUOUS running and maybe more. A little roughness is easily removed, but if allowed to increase it will soon be too late for any remedy except the lathe.

The commutator should at all times present a clean and polished surface and a true circumference. It is in its best condition when it presents a dark glazed surface, free from scratches. If accidentally scratched it may be polished with No. 00 sand paper moistened with a drop of sperm oil or vaseline, and cleaned with a piece of canvas or chamois skin. ***Emery paper or emery cloth should not be used to scour the commutator,*** as the fine particles of emery, settling in the divisions between the bars, may cause short circuiting at the commutator. A file should not be employed.

Waste should not be used to clean the commutator, as the lint is apt to get under the brushes and cause sparking.

Avoid the use of all special kinds of grease or wax offered for sale for use on commutators; they do much more evil than good, and should not be permitted in the station.

If the commutator is but slightly rough or uneven or out of true, it may be ground down by the use of sand paper in a block hollowed out to fit its true circumference. If in very bad condition, however, it should be turned down with a tool and special rest.

For turning off commutators a slide rest can be obtained of the Edison Machine Works and is made to attach to the dynamo bed, this will save removing the armature, provided a proper slow speed can be had. If an armature has to be removed for any cause *the greatest pains must be taken in handling. Armatures are often burned out because of some blow or bruise received from careless handling.*

Don't lay an armature on the floor unless some sort of cushion is placed underneath. Armatures should be lifted and carried by the shaft as far as possible.

In turning off commutator the cut should stop before reaching the end of the bar. This is important to preserve the insulation and to keep the iron collars intact for receiving a new set of bars.

The amount of wear on commutator which may be allowed before sending to shops for repairs depends on the depth of the commutator bars, and the amount of current they are required to carry. This varies in the different machines.

The safe depth to which the commutator may be worn in each machine should be known, and a new commutator supplied before the dangerous point is reached.

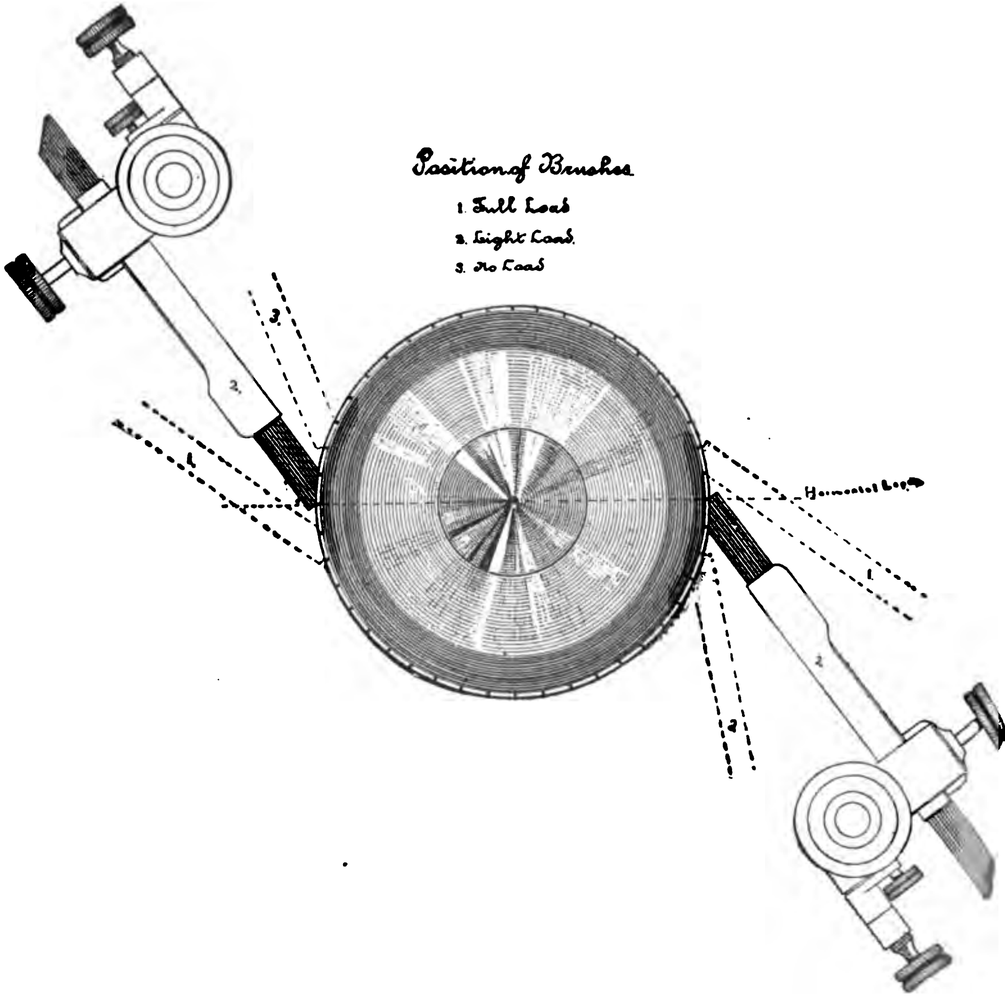
The following table shows the original diameter of commutator and the diameter to which it may be safely worn for different sizes of dynamos:

Dynamo.	Diameter of Commutator.	Diameter to which it may be Worn.
No. 1.	$3\frac{11}{32}''$	$2\frac{1}{2}'$
No. 2.	$3\frac{1}{2}''$	$2\frac{9}{16}''$
No. 3.	$3\frac{7}{8}''$	$2\frac{15}{16}''$
No. 4.	$4\frac{1}{2}''$	$3\frac{3}{16}''$
No. 6.	$4\frac{13}{16}''$	$3\frac{9}{16}''$
No. 8.	$5\frac{1}{4}''$	$4''$
No. 10.	$5\frac{13}{16}''$	$4\frac{1}{2}''$
No. 12.	$6\frac{5}{16}''$	$4\frac{15}{16}''$
No. 16.	$6\frac{13}{16}''$	$5\frac{7}{16}''$
No. 20.	$6\frac{7}{8}''$	$5\frac{1}{2}''$
No. 32.	$9\frac{5}{16}''$	$6\frac{7}{8}''$
No. 60.	$12\frac{1}{2}''$	$9\frac{7}{8}''$

It is assumed that the diameter is kept the same for the whole length of the commutator, and that the section of the bars at the dangerous point is just equal to the section of the wire of the armature.

It sometimes happens that a bar in the commutator will spring up and stand a little higher than the rest. This will cause the brush to vibrate, and occasion sparking on account of imperfect contact. The dynamo should be stopped as soon as possible, and the high bar carefully filed down to a true circumference.

The Neutral Point.



The neutral points of a dynamo are those positins on the commutator between which the difference of potential is the greatest and where there is the least difference of potential between adjacent bars. These points are diametrically opposite.

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The position where there is no sparking of the brushes or the non-sparking point does not exactly coincide with the neutral point when there is a load on the machine. The non-sparking point advances faster than the point of highest electro-motive force, and they are further apart the greater the load.

The neutral point changes with the change of load. With a slight load the neutral point is near the extremities of a horizontal diameter. As the load increases the neutral point moves forward in the direction of rotation, and the brushes must be advanced to the non-sparking point.

ADJUSTMENT OF BRUSHES.

IN order to maintain the commutator in proper condition and reduce the wear to a minimum, it is vitally necessary that a proper adjustment of the brushes be secured. They should work absolutely free from sparks. Any sparking whatever indicates a bad condition of the commutator or defective adjustment of the brushes.

The brushes should be firmly fastened in the holders in order to insure good conductivity and avoid heating, and placed at the proper angle to secure the best contact surface.

The end of the brush should be carefully beveled so as to conform accurately with the surface of the commutator. The brush should bear lightly upon the commutator, and every part of the beveled end should rest upon it. The pressure should be just sufficient to insure good contact and avoid all cutting and scratching.

One of the worst causes of sparking is lack of pressure of the brush on the commutator, caused by improper setting of the brush holder stud or by allowing a brush to wear too short. The proper angle of the end of the brush is about 45 degrees. To maintain this as the brush wears it must be pushed forward in the holder from time to time. If this is not attended to the brush holder will be held up on the stop pin, pressure is relieved and imperfect contact or none at all is the result.

When at rest the brushes should always be raised from the commutator, and held away by the clips provided for the purpose.

If left in contact with the commutator they are liable to be injured or perhaps ruined by an accidental reversing of the direction of rotation.

The ends of the brushes where they rest upon the commutator should not be allowed to become dirty, rough or ragged, nor should the strands be allowed to spread.

The brushes should at frequent intervals be removed, edges trimmed, ends filed and reset.

They may be cleaned from oil by washing in benzine.

Edison dynamos can be operated under full load with absolutely no spark at the brushes.

It is very necessary that persons in charge of dynamos fully appreciate this fact, and always aim to secure this condition of operation.

A dynamo in operation with a spark at brushes is *prima facie* evidence of carelessness or ignorance on the part of the attendant, and no central station manager should tolerate such a condition of affairs or accept any excuse whatever for its continuance.

Before starting up, the brushes must be adjusted so that their ends rest on the commutator at diametrically opposite points. Opposite bars of the commutator can be found by counting them.

Table Giving Number of Sections in Commutators of Different Sizes of Dynamos.

Nos.	1	2	3	4	6	8	10	12	16	20	32	60
Sections.....	44	58	48	50	48	66	66	58	52	50	48	41

As a result of the brushes not being diametrically opposite, it will be impossible to get them both exactly on the neutral point, and a spark will be produced.

Sparking at the brushes results from a variety of causes.

Sparking is expensive and detrimental chiefly because it results in burning the brushes and commutator, hastening their frequent renewal. Every spark consumes a particle of copper, torn from the commutator or brush. The longer the sparking continues the greater the evil becomes, and the remedy must be applied without delay.

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Causes of Sparking and Remedies.

1st C. Brushes not set at neutral point.

R. The brushes having been previously set diametrically opposite, they can be readily adjusted to the neutral point by moving the rocker arm backward or forward umtil the non-sparking point is found.

2d C. Brushes not set at diametrically opposite points.

R. Great care must be taken to have the brushes set diametrically opposite before starting, as their readjustment while running is troublesome. If any individual brush sparks while the other brushes are working perfectly, it is out of alignment.

To adjust, shift brush in holder and ascertain non-sparking point by trial and error method.

3d C. Brushes set so as not to get full bevel to the circumference of commutator.

R. If brushes are set crooked, and do not bear evenly on the commutator, sparking is apt to result.

Readjustment must be made to secure full face of brush at proper bevel.

4th C. Brushes set with insufficient pressure.

R. This fault can often be remedied by increasing tension on spring in brush holder.

If all brushes on same side have too little pressure, loosen large nut on end of brush-holder bar and turn bar

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slightly, toward commutator, tighten nut firmly and give careful attention to adjustment of spring. This can be done when dynamo is stopped.

5th C. Brushes spread apart and filled with dirt and oil.

R. Oil and copper dust and dirt will fill in between the wires and spread the brushes. All this can be removed by a thorough washing in benzine, or in a hot solution of sal-soda water, or strong potash water. With proper care this will not require to be done oftener than once a week.

6th C. Brush having loose or crooked wire on edge.

R. Loose or crooked wires on edge of brushes are usually caused by careless management in putting brush in holder.

If this trouble occurs accidentally while in operation, carefully bend the loose wire back and clip it off close to the body of the brush.

Any loose wire causing sparking should be removed.

7th C. Brush with hard burnt ends, which destroy its pliability and increase the resistance at contact with the commutator.

R. Brushes, if so badly burned that pliability is lost, must be thrown away; but, if still pliable and of sufficient length, cut off the burnt portion and file to proper bevel in the brush filing jig.

8th C. Commutator bars loose, high or low.

R. A single high bar in the commutator will vibrate the brush, causing poor contact, and consequent sparking.

A heavier tension must be applied to the spring of the brushes until the run is over. As soon as possible the dynamo should be stopped and the high bar carefully repaired.

If commutator bars are loose, screw up the ring at end of commutator.

If bar is high, set it down in place with a wooden mallet and screw up the ring.

If bar is low, screw the ring up firmly in place and turn the commutator down to a true circumference, or grind it down with sand paper in a hollow block.

9th C. Loose connection between armature coil and commutator bar.

R. A loose or broken connection between commutator and armature coil will cause a peculiar blue snapping spark, just as the bar leading to it is passing under the brush.

This will show itself on the particular bar having the loose connection.

This spark cannot be wholly remedied while running. The spark may be diminished by setting one brush on each side a little in advance of the other. The dynamo should be stopped as soon as possible and the connection of the armature carefully examined and any loose joints properly repaired.

Take off covering over connections, loosen screws holding connections together.

See to it that the soldering on joint is thoroughly sweated in, and the little pocket holding ends of wire is filled with clean solder, making a perfect joint.

Clean all surfaces, tighten up screws firmly, and renew canvas covering over end of armature.

Be sure that this covering is always strong and whole, do not permit it to get ragged and let in copper dust.

10th C. Section short circuited, either in commutator or armature coils.

R. This fault cannot be repaired in station unless there is an expert man on hand who knows how to wind an armature. The armature will probably require to be sent to Machine Works for repairs.

11th C. Armature damp, with consequent short circuiting of coils.

R. A damp armature can generally be dried out by setting it near a stove or steam radiator, where it will be exposed to moderate heat.

12th C. Short circuit or cross on outside system.

R. A cross will cause brushes to spark and sputter severely. The cross must be burnt out promptly.

13th C. Commutator dirty, oily, rough, worn in ridges, or out of true circumference.

R. Oil and dirt can be wiped off with a piece of canvas or chamois ; then polish commutator with fine sand paper. Ridges should be scoured down with sand

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Note.—See special instructions.

paper. A commutator out of true should be turned down with a tool and slide rest, using a slow speed and a fine cut (see special instructions, page 44).

14th C. Dynamo overloaded.

R. This cause of sparking is easily detected at the ampère meter. The proper measures should be taken at once to relieve the dynamo. If the load on a pair is unequally divided, it should be properly regulated by means of the resistance boxes. If due to a heavy load of lamps, or short circuit on the line, the overloaded dynamo can be relieved by throwing an additional dynamo in multiple arc with it.

As an amperè meter is not infallible it is well to notice the temperature of the armature if a dynamo is doing heavy duty.

The test of temperature can be made by laying a glass thermometer close against the armature immediately on stopping the dynamo, cover the thermometer with a piece of clean waste to avoid effects of outside temperature, leave it in contact for about five minutes and note temperature quickly on removal.

100° Cent. is a safe temperature.

If the lamps connected on the system are so great in number as to cause an overload of all dynamos every night, then an additional pair of dynamos should be ordered at once.

15th C. Armature coils or commutator sections short circuited by accumulation of copper dust.

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R. An examination of some dynamos would lead a man to believe the machine was constructed for the purpose of producing copper dust.

The accumulation of copper dust on a dynamo and its gradual penetration into the coils of armature and fields is often the real cause of serious accident and expensive repairs.

This is one of the principal features which denotes carelessness and inefficient management and an utter lack of appreciation of the importance of cleanliness about dynamos and electrical apparatus.

The remedy is easy to apply; the dynamos MUST be kept clean of oil and copper dust.

FAULTS AND ACCIDENTS.

IT is only in times of accident that we develop in a central station superintendent some of the most necessary qualifications for his work, or that his inability is made manifest. Presence of mind, calm judgment, quick action—all combined—enabling him to do just the right thing in an emergency on the spur of the moment, are all important.

When accidents happen in an electric light station they come quick, and no time is to be lost in applying the proper remedy.

Experience and perfection of system has enabled us largely to avoid troubles which in early days were of frequent occurrence.

The faults and accidents to which dynamos are liable are very rare, and may be largely avoided by careful inspection and proper care. When accidents occur the cause must be quickly perceived and the remedy intelligently applied.

The following are some of the disorders :

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Burning out Armature Coil.

This may be occasioned by overloading the armature, causing the insulation of the coils to give way, and is indicated by the armature suddenly beginning to smoke. The coil is thus rendered useless. As a temporary makeshift, the injured coil may be disconnected from the commutator, the ends insulated with tape, and the two adjacent bars to which the coil was connected joined to each other by a wire not smaller than the armature wire.

The machine can be operated for a time in this way, but a new armature should be put in as soon as possible.

Ring of Fire Around the Commutator.

This is caused by small particles of copper between the bars of the commutator, making a local short circuit from bar to bar across the mica insulation.

To remedy it clean the commutator carefully, and do not allow the brushes to cut and scratch it.

Breaking Down of One Dynamo.

If one dynamo of a single pair connected in series on a 3-wire system breaks down from any cause, the result will be merely to put out the lights on that side of the system.

If, however, other dynamos are in multiple with the disabled machine, the current through its armature will be reversed, and it will run as a motor if not disabled electrically.

In any case it should be thrown off the system at once by

Reversal of Polarity of Magnets.

Reversal of polarity of a dynamo which is one of two or more connected in multiple is equivalent to a dead short circuit, and, if it does not blow a fuse or throw off a belt, will probably burn out an armature.

Reversal of polarity of one of a single pair of dynamos working in series on a three-wire system will tend to send all the current through the neutral wire, which will cause the lights to burn dim, and charge up the current to the company on all meters on the reversed side.

If the reversed dynamo should be switched in with another not reversed on the same side further trouble is caused. If dynamos supplying current through meters should be all reversed the meters will all be caused to read backward.

Any man having a dynamo under his care should be perfectly familiar with the proper methods of charging a reversed or demagnetized field.

A compass for testing polarity can be had for a small sum. In an emergency a magnetized steel needle attached to a silk thread will answer every purpose. Don't trust to the mark on the compass, but see for yourself which way it points, and remember that the north pole of the compass points to the south pole of the dynamo.

Dynamos on the three-wire system may be reversed under the following conditions :

A reversal of the polarity of the field magnets sometimes takes place when starting up.

This may be due to the influence of another dynamo in close proximity to it.

The induction of a strong magnet may be sufficient to reverse the slight permanent magnetism of the dynamo at rest.

The field of a dynamo may be reversed by the current of a second dynamo in series with it while in operation, if the brushes of the first dynamo are accidentally raised or its current broken in any way between the points to which the field circuit is connected.

The dynamo should immediately be thrown out and its field properly charged.

By lifting the brushes before throwing out the switch.

By burning out the safety catches which are on some of the dynamos.

By crosses on the lines.

By 200 volt motors. This is more apt to occur during a light load when the motor is thrown on with a heavy load.

If one side of the system becomes reversed it will show the fact by low pressure and by the indicators on that side reversing, and by the neutral "bus" becoming very hot and the neutral ampère meter indicating a very heavy load; also, no difference of potential between + and — "bus."

To correct the machines open the circuit switch, raise the brushes and throw the dynamo-changing switch on the side not reversed, and leave it about a minute. Then, after raising the field on it, test the polarity of the machine with test paper. If part of the machines are demagnetized the same process may be followed.

Effects of Lightning.

Lightning is to be feared as a property-destroying agent merely. One of the safest places to be in during a thunder storm is an electric light station. Where damage has happened to a dynamo caused by lightning, the occasion has been found in the absence of the proper safeguards or in some faulty work in connection with them.

No effects of lightning will be felt on Edison systems with street conductors entirely underground. Where there are very long outdoor pole lines similar effects occur as on telegraph and telephone lines, and somewhat similar precautions should be taken to prevent injury to apparatus.

The usual result of lightning freaks are the breaking of lamp carbons, melting fuses, and damaging of dynamos by injury to the insulation in some part or reversing and demagnetizing.

For the protection of the dynamo in systems having long overhead lines special precautions should be taken in the way of perfectly insulating the base from the ground. Direct connection of water or drip pipes to the dynamo is to be avoided, and even the proximity of such pipes when lightning is specially to be guarded against is objected to. Lightning arresters when used should be in plain sight. Fuses on such arresters must be promptly replaced. Ground wires and connections are particularly important and must be kept intact and in good condition.

The following will always guide you in recharging a dynamo :

I.—Raise the brushes of the demagnetized or reversed dynamo.

II.—By the double changing switch throw it in multiple arc with one which is running all right (on either side of the system).

III.—Close the single dynamo switch for an instant.

This does not take over thirty seconds.

The previous instructions given for tests of field and armatures for crosses and grounds, and also for demagnetization and reversal of polarity fully cover the important points for immediate investigation of damage and the proper remedy to apply.

Crosses on Street Conductors.

These troubles are not of frequent occurrence and principally happen on overhead systems, due to severe storms causing the dropping of telephone or telegraph wires across the electric light circuits.

It is estimated that all crosses can be prevented by the use of wire having durable weather proof insulation, and by careful and thorough construction of the pole line system. Nevertheless, the fact remains (that in the absence of these precautions, in many cases due to lack of sufficient original investment) that crosses occur, and it therefore becomes our duty to give such instructions as will enable the station operator to promptly clear his lines and thus avoid more serious damage.

In this particular matter the operatives must work with promptness and decision.

When a leak appears on the system, whether a ground or a cross, additional dynamos must be thrown in on the faulty side. As much current as possible must be forced into the leak, in order to burn out the fault or safety fuses, if possible, and to keep the lights up to candle power.

The fault should be located and corrected at once.

If a heavy cross or ground shows on the line, and the lights burn low or go out, vigorous measures must be taken at once. Such a fault usually occurs when there is a light load on the system, and insufficient current being generated to melt the safety fuses.

To clear out the cross, start up two or three dynamos, and get their pressures up until the pilot lamps show somewhat less than full candle power.

The changing switches should be so adjusted as to throw all the dynamos on the faulty side.

Then everything being in readiness, at a given signal close all the circuit switches. At the same instant the rocker arm should be pulled over and the brushes adjusted. To achieve success, the men must act in unison and quickly.

If the fault is not cleared the dynamos must be thrown out and the operation repeated with more dynamos.

The above-described method is usually successful in clearing the fault or fusing the nearest safety catches, after which the lights on that side will come up again.

Caution.

GREAT care must be taken, when the fault disappears, that the pressure on the system does not come up too high and injure the lamps.

Facts to be Remembered.

1. Be sure that the speed of the dynamo is right.

2. Be sure that all the belts are sufficiently tight.

3. Be sure that all connections are firm and make good contact.

4. Keep every part of the machine and dynamo room scrupulously clean.

5. Keep all the insulations free from metal dust or gritty substances.

6. Do not allow the circuit to become uninsulated in any way.

7. Keep all bearings of the machine well oiled.

8. Keep the brushes properly set and see to it that they do not cut or scratch the commutator.

9. If brushes spark, locate the trouble and rectify it at once, AS NO EXCUSE WILL BE ACCEPTED FOR SPARKING.

10. The durability of the commutator and brushes depends on the care exercised by the person in charge of the dynamos.

11. At intervals the dynamos must be disconnected from the circuit and thoroughlg tested for leakage and grounds.

12. In stations running less than 24 hours per day, the circuit should be thoroughly tested and grounds removed (if any are found) before steam is turned on.

13. Before throwing dynamos in circuit with others running in multiple, be sure the pressure is the same as that of the circuit, then close the switch.

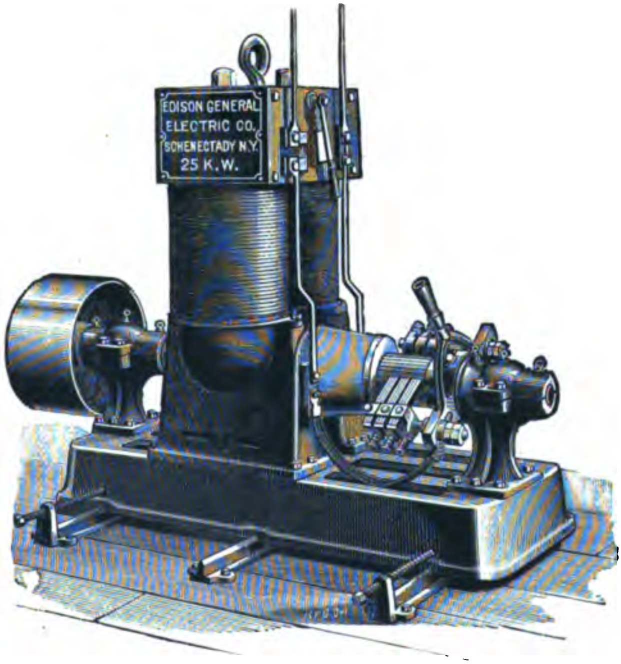
14. Be sure each dynamo in circuit is so regulated as to have its full share of load, and keep it so by use of resistance box.

Each central station manager is advised to drill his subordinates (as far as possible) in all the foregoing details, so as to make them prompt in action and less liable to error in case of emergency.

For further instructions or information please address the nearest District Office.

THE EDISON
Electric : Stationary : Motor.

Light, Portable,
Compact, Simple,
Durable, Economical,


EDISON GENERAL
ELECTRIC CO.
SCHENECTADY N.Y.
25 K.W.

No Fire, No Ashes,
No Water, No Engineer,
No Boiler, No Electrician,

NO EXTRA INSURANCE.

1891.

THE rapid introduction and extension of electric circuits which have taken place during the past few years have caused a widespread demand for an efficient and durable electric motor, and one which can readily be used and cared for by the ordinary power user.

Numerous electric motors have been placed on the market, but ours has met the conditions imposed more successfully than any other as our extensive and constantly increasing sales testify.

For efficiency and adaptability to ALL classes of work our motors are a long way in advance of any other motor yet invented. They have never as yet failed to give satisfaction in any duty assigned them when properly installed and cared for; and their installation is simple and inexpensive, and their operation requires little attention.

Our motors are now well known to power users all over the country, and scientific men, practical electricians and all persons using them, give them a broad and unqualified indorsement.

The points of their excellence and superiority are these:

AUTOMATIC IN REGULATION.

Where constant speed is required with an intermittent load, as in the operation of lathes, circular saws, printing presses, etc., we are prepared to furnish electric motors, the speed of which will not vary with a variation in the load. The regulation of these machines is due wholly to our method of winding, and not to mechanical governors; consequently the governor is inert and there are no moving parts to get out of order.

MECHANICAL CONSTRUCTION.

This is of the very best in material and workmanship. The motors supplied by us are built at our manufactory, at Schenectady, N. Y., the largest electrical supply factory in the world, and our experience in designing and building electrical machinery is *second to none* in this or any foreign country. All the machines are standardized, and the parts made interchangeable.

We keep on hand at our factory a full supply of all sizes and parts of our motors, and can, therefore, fill promptly any order.

ECONOMY.

Considering the work done, the first cost is 25 per cent. less than that of any other make of motor. As there are but few parts of the machine exposed to wear, depreciation is slight. We have known instances of our motors running six months, day and night, without a stop.

SELF-OILING BEARINGS.

The new self-oiling bearings, which are now used on all our Stationary Motors, are much superior to the ordinary style of oil cup or metallic bearings, and secure absolute reliability against heating, as well as perfect lubrication. These bearings do not require attention oftener than about once a week, and the oil does not require renewal as often as that. The supply of oil to the shaft is governed by the requirements of the motor and is absolutely automatic, commencing when the motor is put into operation and stopping with the motor. The general arrangement of the bearings is shown by the illustration on page 7.

NEAT, NOISELESS.

By the use of these bearings all the oil used for lubrication is enclosed within the bearing, and there is no throwing or spattering of oil.

Our new motor is as neat and noiseless as the best made sewing machine.

NON-SPARKING.

The motor is non-sparking, due to the neutral point being held fixed under the brushes, and not changing by variation in load. This feature is a source of great economy in the maintenance and life of the motor.

SAFE.

For general distribution of power our motors are absolutely harmless to persons and property.

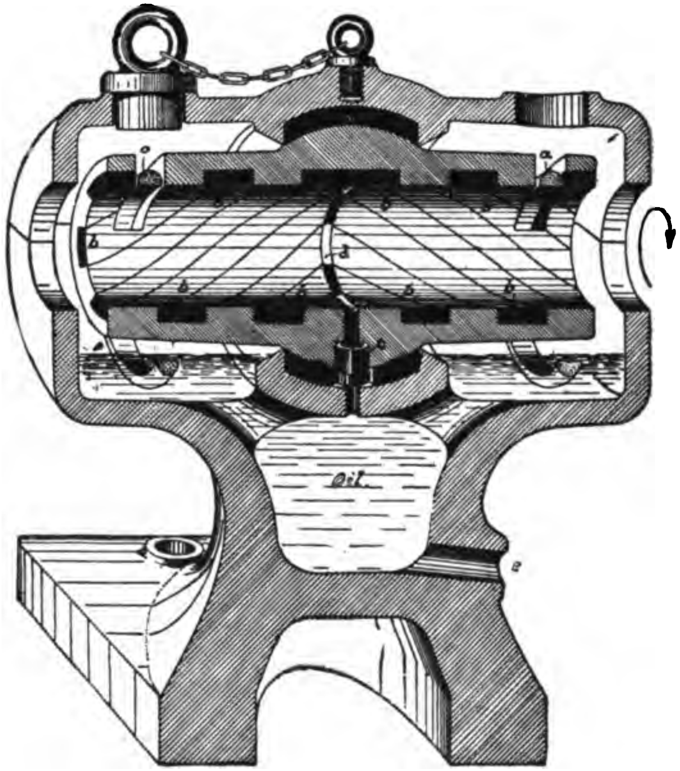
366

SELF-OILING BEARING.

The construction of our Self-Oiling Bearing is shown in the above cut. The revolving rings *a* carry from the reservoir to both ends of the sleeve a continual supply of oil which is swept by the action of the revolving shaft, on the spirals *b* towards the center of the bearing, where it is collected by the central groove *d*, and returned by the hole *c* to the reservoir, where it has time to settle and cool.

By these means a continual circulation of oil through the bearing is automatically started, kept up and stopped by the motion of the shaft, the bearings requiring no attention beyond a periodical examination, and, when necessary, renewal of the oil, which may be drawn off from the reservoir at *e*.

This bearing will only act for running in one direction; for the bearing in the sketch the arrow shows the direction of rotation. To run the shaft the other way the sleeve would have to be turned end for end. It is, therefore, *imperative* that the bearings be correctly put together. For this purpose an arrow is stamped on the upper surface of the ball bearing of the sleeve, and the latter must be set so that looking down on the bearing the upper surface of the shaft runs in the direction that the arrow points.



Self-Oiling Bearing.

CONVENIENT.

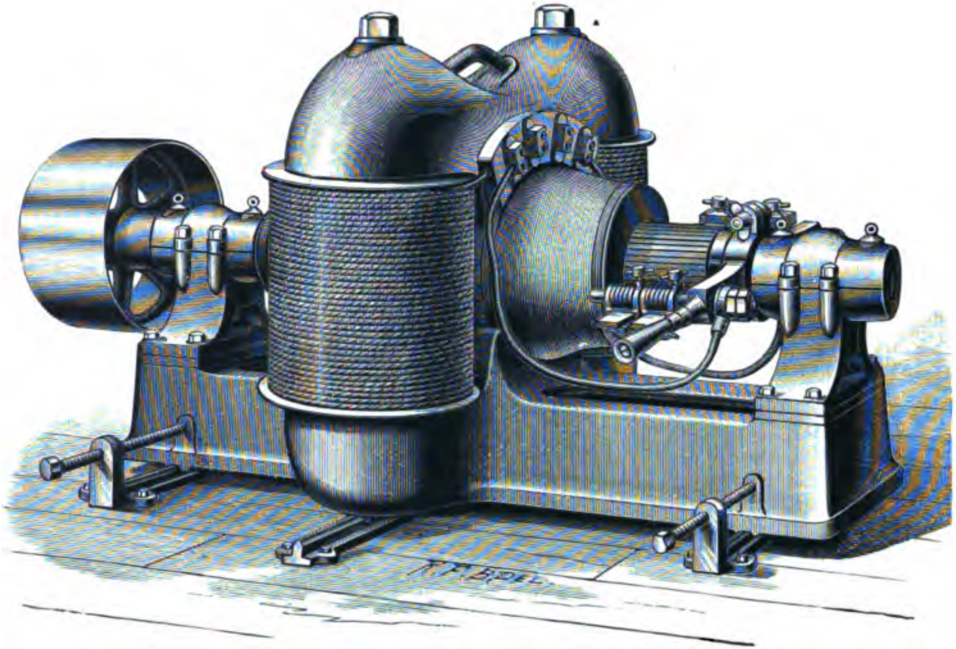
Our motors are mounted on rails, as shown in the illustration on page 1, and their distance from the machine or countershaft can be varied by the rail bolts, and any belt slack can thus be taken up. Four brushes, with the same number of brush holders, are used, by means of which the position and tension of the brushes on the commutator can be varied. Other details of mechanical and electrical construction which add to the ease of operating these motors have been adopted, so that they are now the most convenient and reliable of any on the market.

COMPACT.

Another advantage, and a most important one, too, is the remarkable saving of space for machinery. As much as 25 H. P. of our electrical machinery for power can be set up in a space of less than five feet square.

An instance of the convenience of this economy of space is shown on page 11, where the entire motive power for operating an elevator at the building of the Manufacturers' National Bank is supplied by the motor, which is mounted on a stand and does not occupy valuable space.

To real estate owners this means that the upper stories of their buildings are as rentable for manufacturing purposes as if there was steam power in the building, while the cost of insurance is not increased as would be the case if a steam plant was introduced.



View of 50 Horse Power Edison Stationary Motor (old style).

SIMPLE.

Our motors are much simpler to operate than a steam, gas, water or any other style of motor, and all the knowledge necessary to their proper care can be easily acquired by any painstaking person. Full instructions in regard to the care of motors accompany each machine.

SIZES AND HORSE POWER.

The motors are of all sizes, from one-tenth horse power to one hundred and fifty horse power. The horse power is in all cases guaranteed by certificate with each motor.

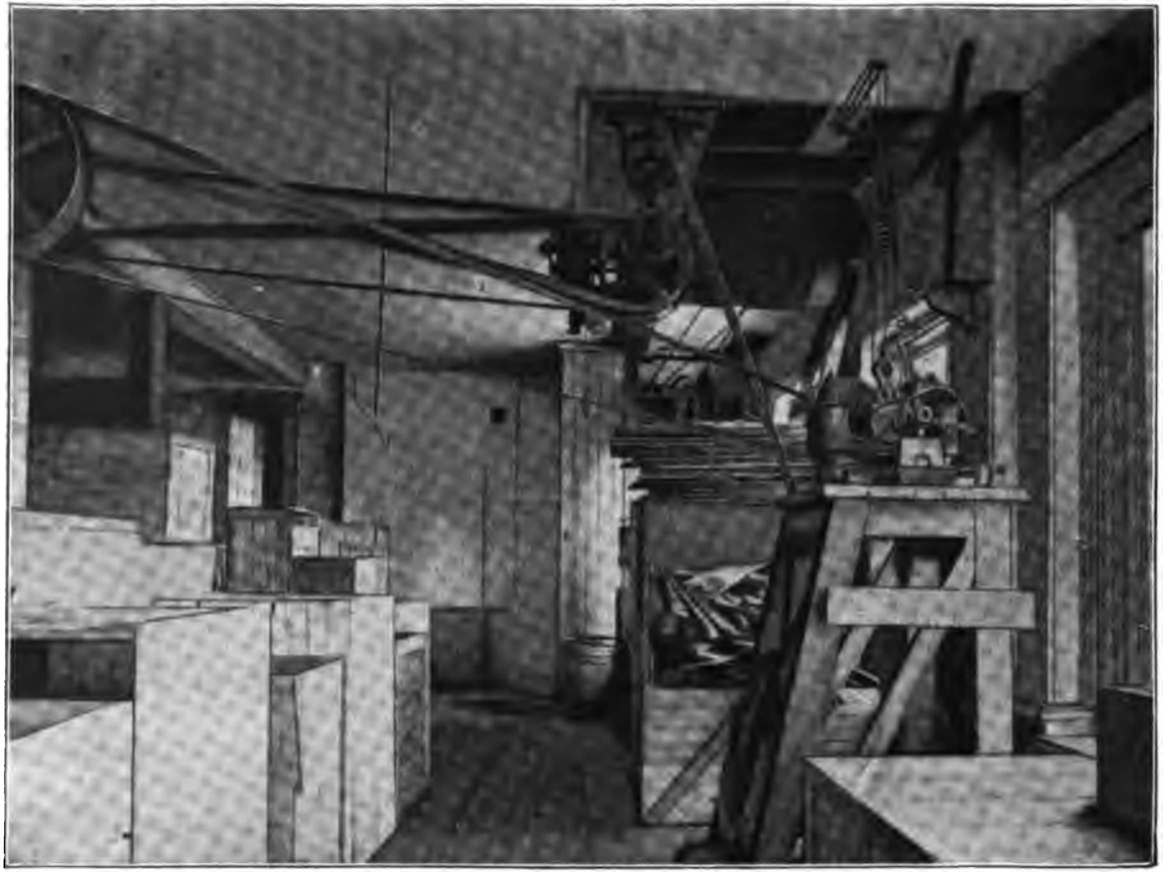
STYLES OF MOTORS.

We have a variety of methods for winding our motors, depending upon the kind of work to be performed by them.

Full information in regard to the most desirable styles of winding for particular classes of work can be obtained at our head office in New York, or at any of our branch offices.

SUPERIORITY TO OTHER METHODS.

Transmitted power by the electric system using our motors has great advantages over steam, water, gas, compressed air or wire rope. Its system of conductors is far more flexible in its arrangements, and is capable of a more ready ramification and distribution than any other of its competitors. It is operated under much higher pressure, and so can be distributed with smaller conductors and much less investment of time, labor and money.



View of 5 Horse Power Motor, operating direct Hoist Freight Elevator at Manufacturers' National Bank, Summer Street, Boston.

ADAPTATION UNIVERSAL.

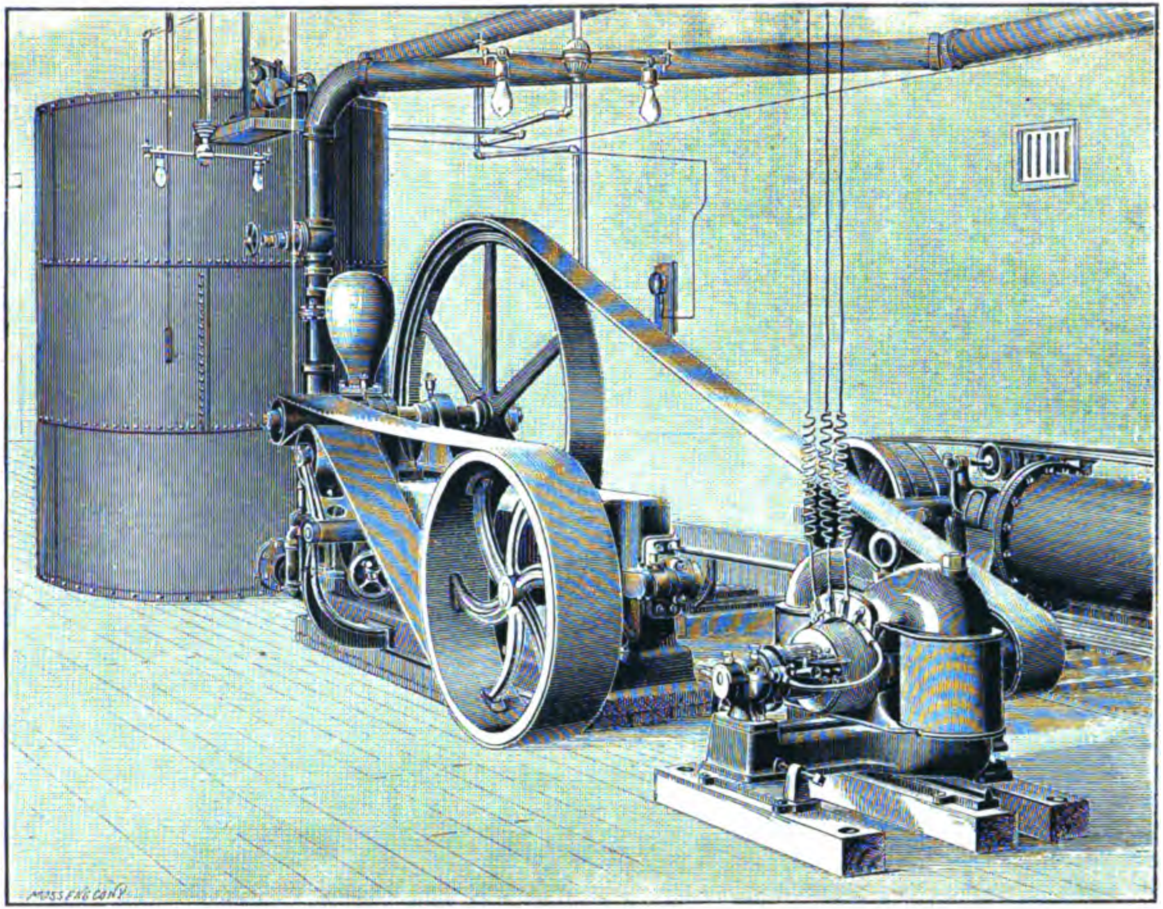
Any work that a steam engine can do can be done by our motor, and in most cases will be done with more satisfaction and economy. Our motors are now used in more than one hundred and fifty varieties of industry in this country. One of the most important, as well as exacting, of these industries, is that of elevator work, in houses, hotels, warehouses, mills, etc.

A careful test was made some time ago as to the amount of energy delivered by one of our 15 H. P. motors to a couple of fast speed freight elevators, running in the paper warehouse of Carter, Rice & Co., of Boston.

The trial was made with an Emerson Power Scale, under the direction of J. W. Clark, architect, assisted by Professors Lanza and Puffer, of the Institute of Technology. The results show a development of the full guaranteed horse power of the motor, an efficiency of over 90 per cent., and a result in every way satisfactory.

MILL USE.

It has been demonstrated in practical use, that as large a per cent. of reconverted power from our motor can be delivered for work from the motor pulleys as can be obtained in the average mill by direct application by belts and shafting.



15 H. P. Motor operating Elevator at Building of the United Security and Trust Co., 603 Chestnut Street, Philadelphia. This Motor replaced a Gas Engine.

LONG DISTANCE TRANSMISSION OF POWER.

For the long distance transmission of power from water falls or other cheap sources of energy we are prepared to furnish motors wound for the necessary high voltage. To facilitate the installation of such plants, we have standarized motors wound for twelve hundred volts, and any horse power up to 150 horse power. We have patterns ready for supplying on short notice special motors for any voltage up to 6,000 volts, and any horse power up to 600 horse power.

SPECIAL APPLICATIONS.

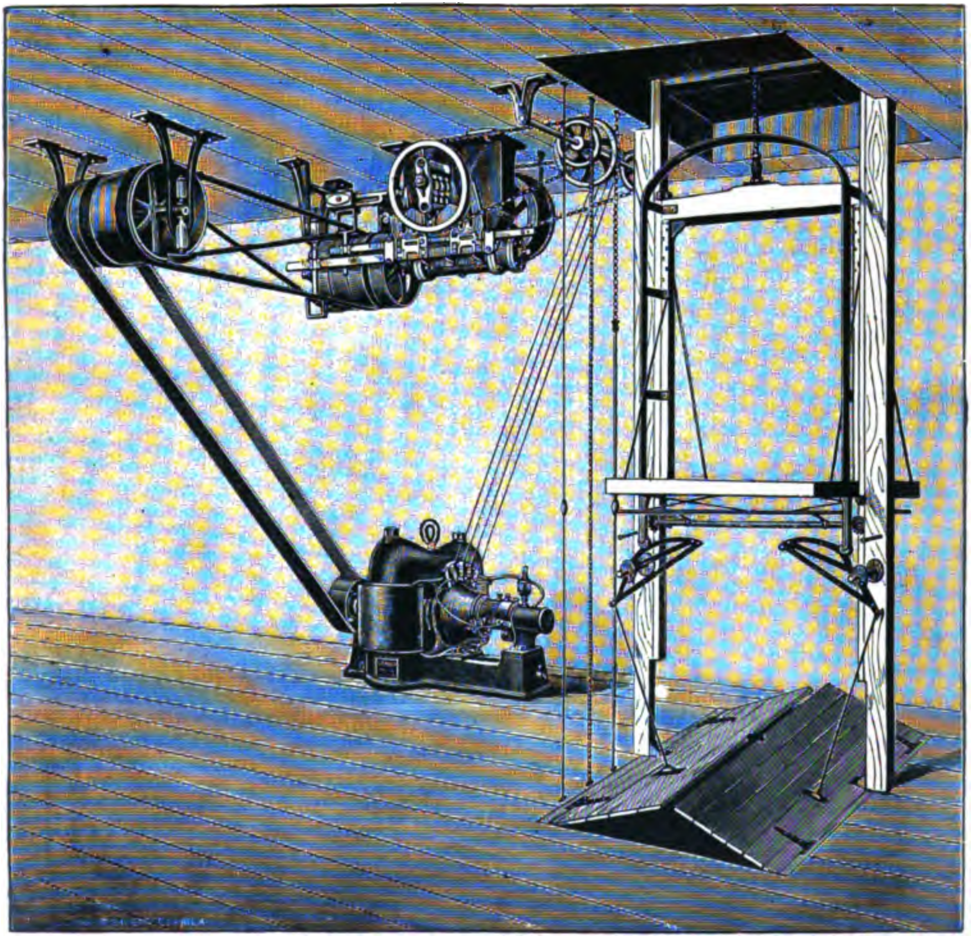
We illustrate in this circular several types of our special motor applications. One of these is an electric hoist, and the other is a combination of electric motor and fan. We are constantly at work at designing and manufacturing these special applications, and will be pleased to undertake any work of this character, for which our large facilities in the line of designing and manufacturing give us special advantages.

ELECTRIC CIRCUITS.

Our standard motors can be used on any constant potential, direct current, electric circuit. Most circuits operating incandescent electric lamps, and most street railway circuits are of this character.

COST OF OPERATION.

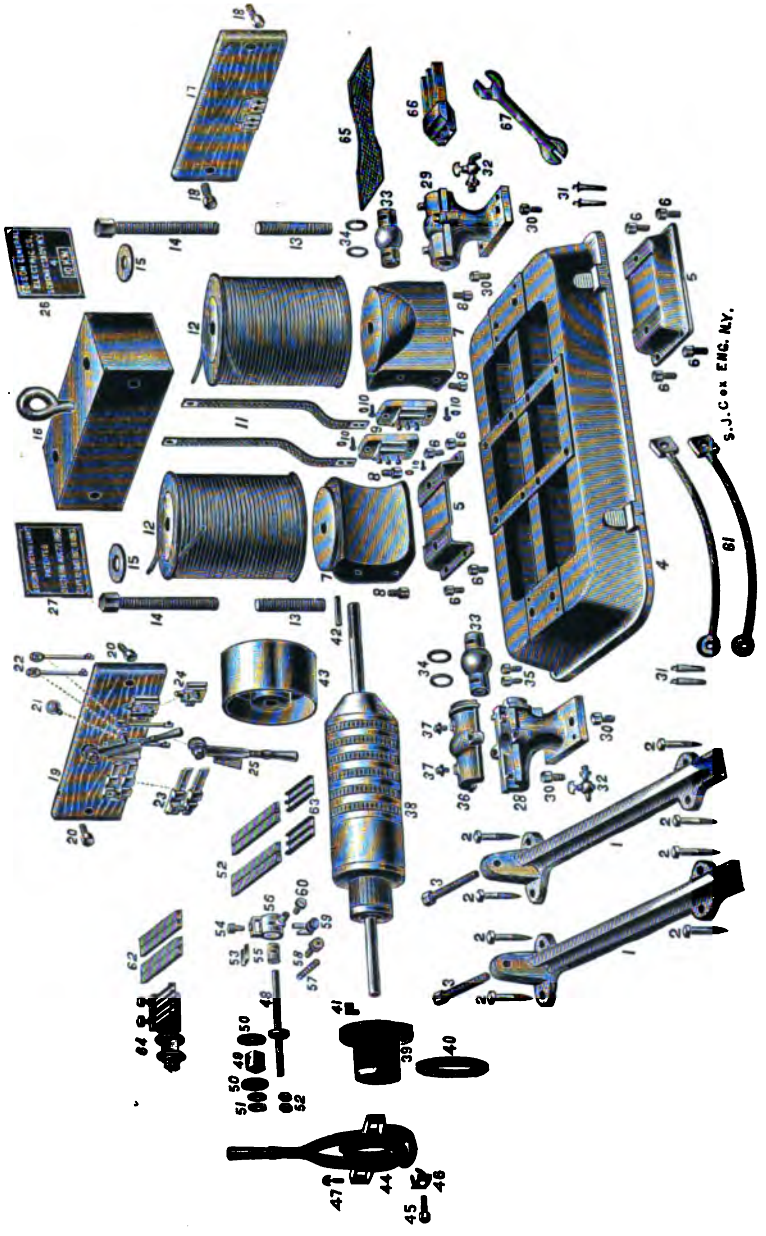
The prices charged by electric companies for current for operating our motors vary in different localities, but the average price per year, where the motor is used ten hours per day, is about $100.00 per horse power for motors up to 5 horse power, and a less rate for larger sizes of motors. Exact prices can be obtained upon application, with necessary information in any particular case.



This cut illustrates an Elevator at the Union Stove Works, 70 Beekman Street, New York City, operated by an Edison Motor. This Motor is doing very heavy work in lifting furnaces, ranges, stoves, etc. The view shows the general method of attaching to belt elevators.

TESTIMONIALS.

We are in receipt of a large number of unsolicited testimonials from the users of our motors, speaking in the highest terms of the durability, reliability and convenience of our apparatus. We publish in this pamphlet a list of some of our stationary motor customers in this country. We have in addition to these sales, shipped large numbers of our standard motors to England, France, Germany, Italy, Sweden, Japan, China, Argentine Republic, Transvaal, and other foreign countries.


S.J.Cox ENG. N.Y.

LIST OF PARTS OF EDISON STANDARD MOTOR.

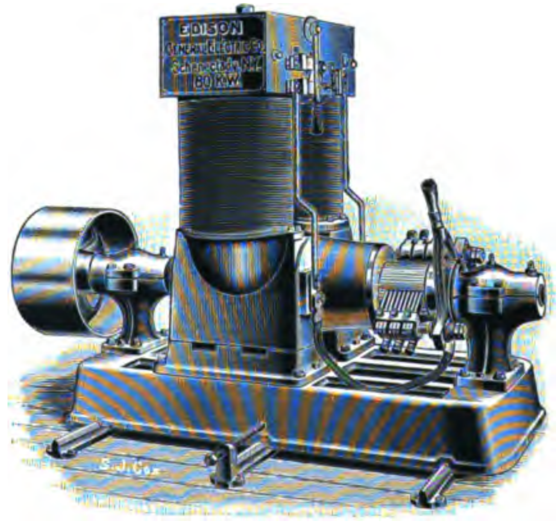
No. 1. Rails.
No. 2. Lag screws for rails.
No. 3. Adjusting screws for rail.
No. 4. Bed plate.
No. 5. Zinc bases for fields.
No. 6. Bolts for securing same to bed plate.
No. 7. Pole Pieces.
No. 8. Bolts for securing same to zinc bases.
No. 9. Lower terminals for motor leads secured to front side of pole pieces.
No. 10. Bolts for securing same to pole pieces.
No. 11. Motor leads from lower terminals to head board.
No. 12. Field coils and cores.
No. 13. Lower screws for attaching field cores to pole pieces.
No. 14. Bolts for attaching keeper to pole pieces.
No. 15. Washers for same.
No. 16. Keeper.
No. 17. Back-board and field coil terminal blocks.
No. 18. Bolts for attaching same to keeper.
No. 19. Motor head-board.
No. 20. Bolts for attaching same to front side of keeper.
No. 21. Stop-stud for the motor head-board switch.
No. 22. Motor head-board field terminals.
No. 23. Left-hand motor lead terminal and switch tongue complete.
No. 24. Right-hand motor lead terminal for head-board.
No. 25. Motor head-board switch bar, including tongue, stud and nut complete.
No. 26. Data plate.
No. 27. Name plate.
No. 28. Lower half of self-oiling bearing, commutator end.
No. 29. Lower and upper half of self-oiling bearing, pulley end.
No. 30. Bolts for securing self-oiling bearing to base plate, either pulley or commutator end.
No. 31. Dowell pins for same.
No. 32. Drip-cock for self-oiling bearings, either pulley or commutator end.
No. 33. Shell for self-oiling bearings, either pulley or commutator end.
No. 34. Rings for self-oiling bearings, either pulley or commutator end.

No. 35. Bolts for securing upper half to lower half of self-oiling bearings, either pulley or commutator end.
No. 36. Upper half of self-oiling bearings, commutator end.
No. 37. Brass plugs for closing oil-holes of upper half of self-oiling bearings, either pulley or commutator end.
No. 38. Armature complete.
No. 39. Commutator complete.
No. 40. Fibre ring for commutator.
No. 41. Brass terminal for end of armature coils.
No. 42. Armature pulley key.
No. 43. Armature pulley.
No. 44. Brush yoke.
No. 45. Bolt for securing same.
No. 46. Spring washer for use with No. 45, for adjusting tension on yoke.
No. 47. Thumb-screw for yoke to secure same to prevent lateral motion.
No. 48. Brush holder stud.
No. 49. Insulating block for brush holder.
No. 50. Insulating rings for brush holder.
No. 51. Brass washers for brush holder terminals.
No. 52. Brass nuts for brush holder studs.
No. 53. Brass pressure trough for brush holder.
No. 54. Bolt for securing brushes in brush holder.
No. 55. Internal rigid cylinder for brush holder.
No. 56. External movable cylinder for brush holder.
No. 57. Spring for adjusting tension between internal and external cylinder of brush holder.
No. 58. Screw for adjusting tension of spring.
No. 59. Screw cam for holding brush out of contact with commutator.
No. 60. Bolt for securing internal cylinder rigidly upon brush holder stud.
No. 61. Brush holder cables.
No. 62. Motor brushes, either side.
No. 63. Brush holder troughs.
No. 64. Brush holder complete.
No. 65. Wire screen for use between field coils protecting armature.
No. 66. Brush filing jig.
No. 67. Motor wrench.

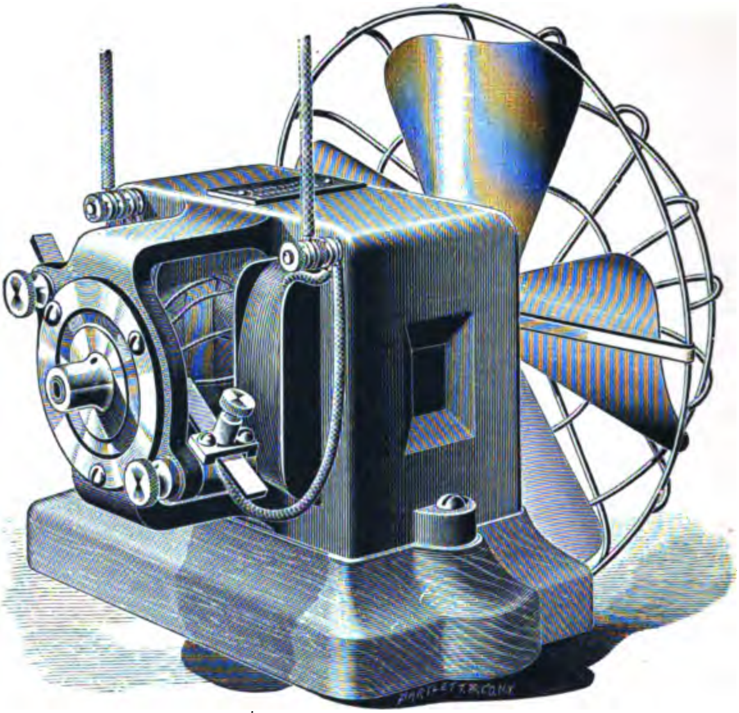
STANDARD CONSTANT POTENTIAL MOTORS.

H. P.	PRICE.				Floor Space.	Height.	WEIGHT IN POUNDS.		PULLEY.			RATED SPEED AT 110 VOLTS.	
	Motor.	Base Frame.	Rheostat.	Total.			Net.	Shipping.	Diameter.	Face.	Bore.	Revolutions per Minute.	Belt Speed per Minute.
¼	$66 00	$3 10	$9 00	$78 10	16 11/16″ x 16″	15″	90	130	3½″	2″	½″	2,100	1,924
½	104 00	3 60	9 00	116 60	21 5/16″ x 16 7/16″	16¼″	120	170	3½″	2½″	⅝″	2.100	1,924
1	160 00	4 45	30 50	194 95	24¼″ x 24¼″	24″	270	330	4″	3″	⅝″	1,800	1,884
2½	283 00	7 85	31 25	322 10	33″ x 28 11/16″	31⅛″	550	655	7½″	3″	⅞″	1,475	2,895
5	466 00	8 45	32 50	506 95	38 11/16″ x 32⅝″	35⅛″	830	1,035	8″	4″	1⅛″	1,385	2,903
7½	....	....	....	....	44⅛″ x 33½″	38⅝″	1,090	1,320	8½″	5″	1¼″	1,315	2,924
10	....	....	....	....	48⅜″ x 33¾″	42⅜″	1,470	1,765	9″	6″	1½″	1,225	2,885
15	....	....	....	....	57″ x 48″	46⅞″	2,130	2,565	11¼″	8″	1⅞″	1,150	3,385
20	....	....	....	....	65 13/16″ x 50¾″	50¾″	2,880	3,075	12″	9″	2⅛″	1,085	3,407
25	....	....	....	....	68 5/16″ x 52¼″	54″	3,570	3,970	13″	10″	2⅜″	990	3,367
30	....	....	....	....	73½″ x 53½″	56⅞″	4,340	4,810	14″	11″	2¾″	925	3,388
40	....	....	....	....	83 9/16″ x 58″	66⅝″	6,800	7,770	17″	12″	3″	765	3,402
50	....	....	....	....	92½″ x 62⅝″	75″	9,790	10,590	24″	13″	3¼″	530	3,328
80	....	....	....	....	105 1/16″ x 68⅜″	82⅜″	16,200	17,500	26″	16″	3¾″	430	2,927
150	....	....	....	....	118⅝″ x 89½″	98″	31,790	34,700	44″	21″	5½″	360	4.147

Prices of Larger Sizes of Motors Furnished on Application. Prices Subject to Discount.



View of 80 Horse Power Edison Stationary Motor (new style).



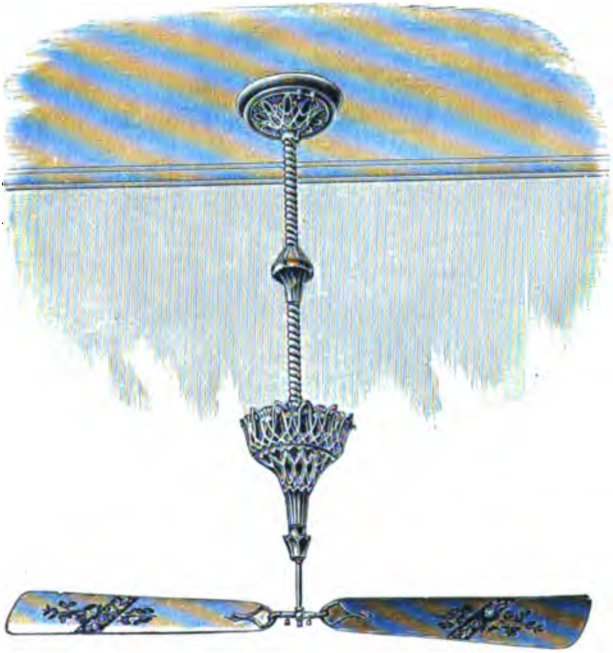
SMALL FAN MOTOR.

F. M. No. 6.

Size.	Space.			Weight.		Watts required at 110 Volts.	Revolutions per Minute at 110 Volts.	Diam. of Fan.	List Price.		
	Length.	Width.	Height.	Net.	Shipping.				Motor and Fan.	Motor, Fan and Guard.	Guard.
⅛	7¾″	6½″	6″	12½ lbs.	14 lbs.	200	2700 to 3000	7½	$27.00	$29.50	$2.50

These Fan Motors require a minimum amount of oil, and all bright parts are ***Nickle-Plated.*** They are very compact and having low centre of gravity, are especially suitable for office desks and other similar places.

Prices subject to Discount.



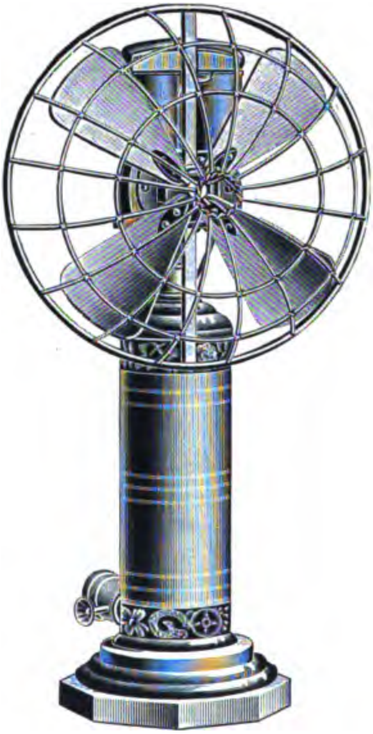
SUSPENDED MOTOR AND FAN.

Rev. per Min.	Length of Wings.	Power Consumed.	Net Weight.	Shipping Weight.
160	4 ft. 6 in.	From 98 to 104 Watts.	87 lbs.	70 lbs.

	Bronzed.	Nickeled.
Price for 12 ft. ceiling........................... ...	$38 00	$40 00

An additional charge of $1.00 per foot will be made for Fans of greater drop than above.

Prices net, subject to change without notice.



PORTABLE ELECTRIC FAN.

Rev. per Min.	Height.	Diam. of Fan.	Price.	Volts.	Amperes.
2300	19¼ inches.	9 inches.	$37 00	106	1.4

Prices subject to discount.

We add here a list of some of the users of our stationary motors.

BOOT AND SHOE MACHINERY.

O. E. Lewis	Boston, Mass.
Bird & Stevens	Boston, Mass.
Bay State Shoe Fastening Co.	Boston, Mass.
Jas. F. Kelly	Milford, Mass.
M. A. Packard & Co	Brockton, Mass.
Thos. White & Co	Brockton, Mass.
H. M. Kingman	Brockton, Mass.
Otis F. Curtis	Brockton, Mass.
Brockton Stay Co	Brockton, Mass.
Given, Morse & Co	Lynn, Mass.
Burns & Co	Lynn, Mass.
Dickinson & Co	Lynn, Mass.
Dickinson, Fisher & Lane	Lynn, Mass.
N. Y. Leather Findings Co	New York City
L. Bonquois	New Orleans, La.
Keiffer Bros	New Orleans, La.
G. H. Congdon	Elgin, Ill.
H. P. Baldwin 2d & Co	Detroit, Mich.
New England Shoe Co	Detroit, Mich.
H. C. Godman	Columbus, O.

BUTTON HOLE MACHINERY.

Excelsior Button Hole Co	Boston, Mass.
Boston Button Hole Co	Boston, Mass.
Morley Shoe Button Co	Boston, Mass.

CARPENTERS' AND ENGRAVERS' MACHINERY.

Boston Photogravure Co	Boston, Mass.
C. H. Codman	Boston, Mass.
T. W. Norman & Co	Boston, Mass.
Boston Copying & Engraving Co	Boston, Mass.
C. M. Thacher	Boston, Mass.
Lewis Engraving Co	Boston, Mass.
James M. Bean	Boston, Mass.
Savage & Co	Boston, Mass.
Jenkes Teaming Co	Woonsocket, R. I.
Woonsocket Coal Co	Woonsocket, R. I.
Woonsocket Machine & Power Co	Woonsocket, R. I.
W. A. Borden	Fall River, Mass.
J. E. Coughlin	Lawrence, Mass.
J. E. Prescott	Lawrence, Mass.
J. M. Foye & Son	Brockton, Mass.
Ward & Logan	Newburgh, N. Y.
Newburgh Training School	Newburgh, N. Y.
J. E. McClees	Philadelphia, Pa.
F. Pulaski & Co	Philadelphia, Pa.
J. L. Stadelman	Ardmore, Pa.
A. Brown	Elgin, Ill.
Wolff Bros	Elgin, Ill.
M. Punchardt	Elgin, Ill.
R. Peters	Chicago, Ill.
Mo. Valley Show Case Works	Kansas City, Mo.

CASH RAILWAY SYSTEMS.

I. D. Allen	Boston, Mass.
Glen Shirt & Collar Co	Boston, Mass.
C. D. Cobb & Co	Boston, Mass.
T. D. Whitney	Boston, Mass.
H. W. Robinson & Co	Brockton, Mass.
Lamson Store Service Co	Lowell, Mass.
Chas. Baum	Washington, D. C.
L. H. Field	Jackson, Mich.

COFFEE MILLS.

F. D. Flagg & Co	Boston, Mass.
Centennial American Tea Co	Boston, Mass.
Henry E. Raymond	Boston, Mass.
Atlantic & Pacific Tea Co	Boston, Mass.
London Tea Co	Boston, Mass.
J. T. Glines & Co	Boston, Mass.
Perkins Bros	Boston, Mass.
Cobb, Bates & Yerxa	Fall River, Mass.
Vernal & Tuell	New Bedford, Mass.
Driscoll, Church & Hall	New Bedford, Mass.
Woonsocket Machine & Power Co	Woonsocket, R. I.
Pawtucket Gas Co	Pawtucket, R. I.
Great Atlantic & Pacific Tea Co	Hartford, Conn.
Newton & Robinson	Hartford, Conn.
Atlantic & Pacific Tea Co	New York City
Atlantic & Pacific Tea Co	Washington, D. C.
Johnson Bros	Washington, D. C.
Metzer Bros	Washington, D. C.
John T. Shaw	New Orleans, La.
Fair Grocery Store	Chicago, Ill.
Grove Feeder Co	Elgin, Ill.
Atlantic & Pacific Tea Co	Louisville, Ky.
J. H. Ferris	Grand Rapids, Mich.
Bonne & Lindsley	Spokane Falls, Wash.

COFFEE ROASTERS.

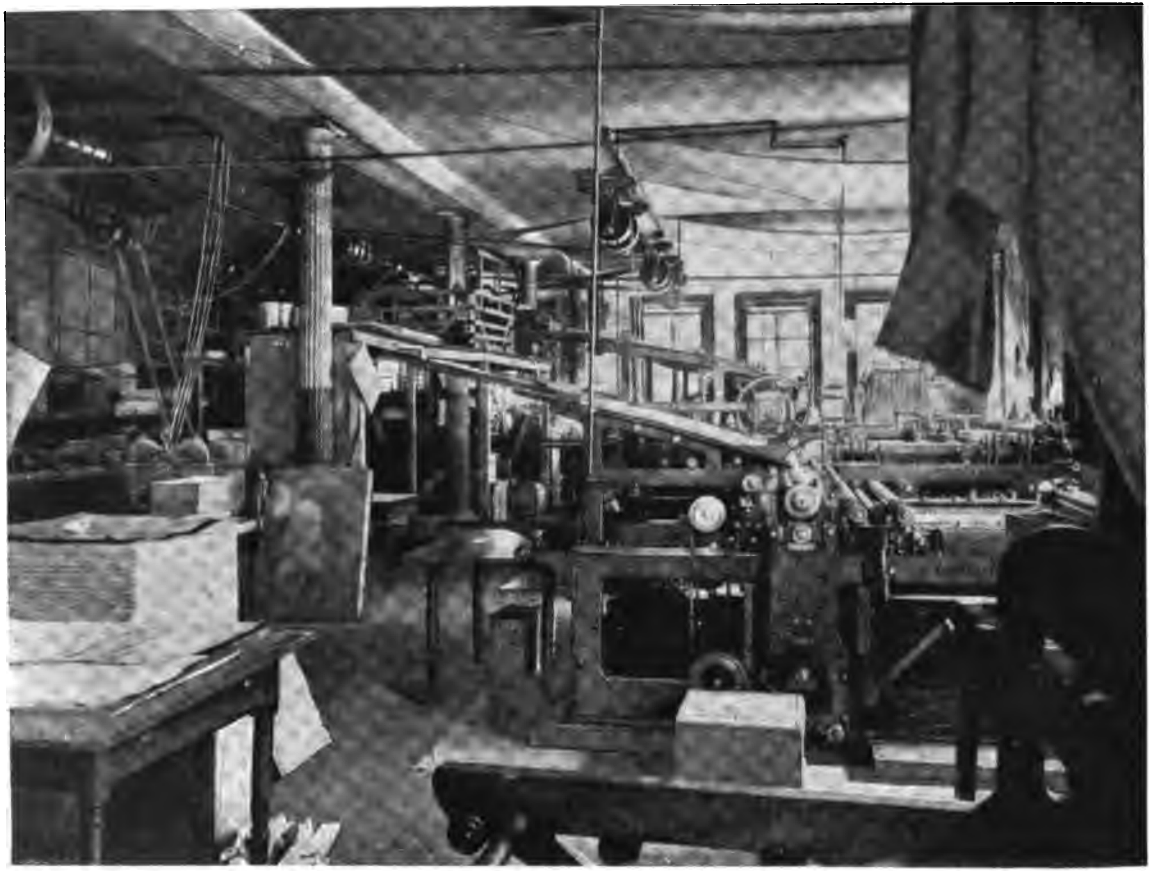
Perkins Bros	Boston, Mass.
J. T. Glines & Co	Boston, Mass.
Johnson Bros	Washington, D. C.
Coddington & Sons	Kearney, Neb.

CONFECTIONERY AND DRUG MILLS.

Otis Clapp & Son	Boston, Mass.
Ridley & Co	New York City
Kalle & Co	New York City
J. A. Flexner	Louisville, Ky.
W. R. Fish	Topeka, Kans.

DENTISTS' MACHINERY, ETC.

Osgood & Flagg	Boston, Mass.
Dr. R. B. Donaldson	Washington, D. C.
Dr. M. F. Lenox	Minneapolis, Minn.
Dr. F. R. Lindley	Kansas City, Mo.
Dr. J. L. Knapp	New Orleans, La.



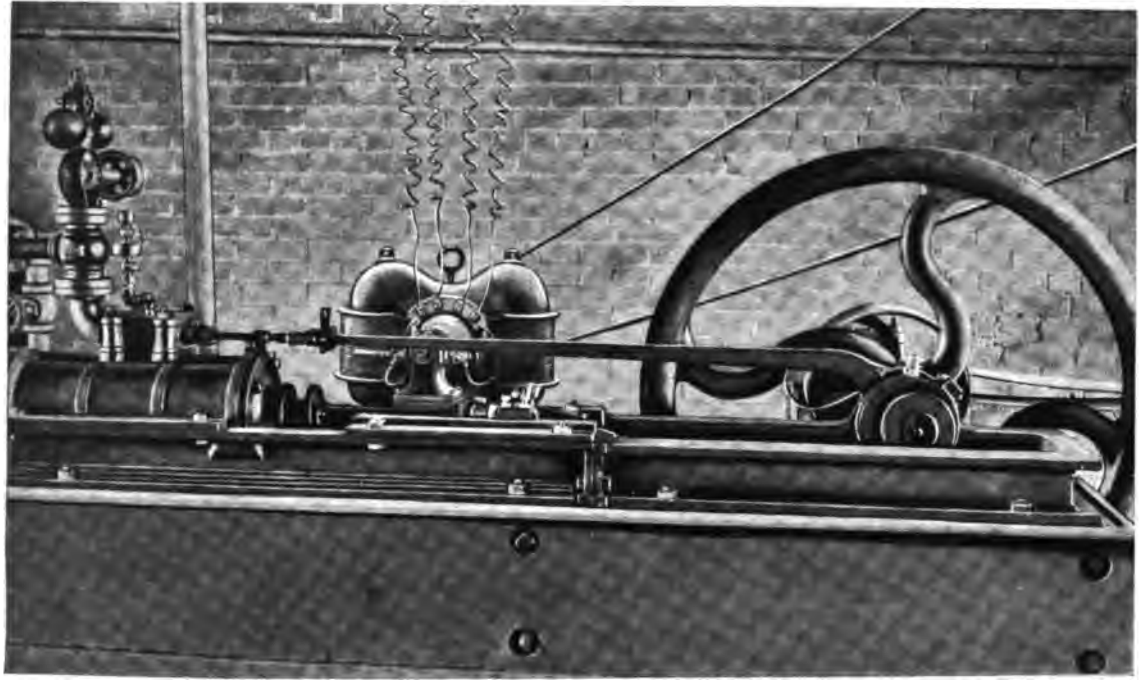
View of 7½ Horse Power Motor operating Printing Presses, Cutters, etc., at the Printing Rooms of the Boston Bank Note and Lithograph Co., 47 Franklin Street, Boston.

DYNAMOS.

Western Union Telegraph Co	Boston, Mass.
C. R. Fleming	New York City
Lanston Type Works	Washington, D. C.
Western Union Telegraph Co	Pittsburgh, Pa.
New Orleans Telephone Co	New Orleans, La.
Tulane University	New Orleans, La.
Ohio Valley Telephone Co	Louisville, Ky.
Western Union Telegraph Co	Chicago, Ill.
Gold & Stock Telegraph Co	Chicago, Ill.
Grand Rapids Telephone Co	Grand Rapids, Mich.
J. B. Timberlake	Jackson, Mich.
Detroit Telephone Co	Detroit, Mich.
Grand Western Telegraph Co	Toronto, Can.

ELEVATORS.

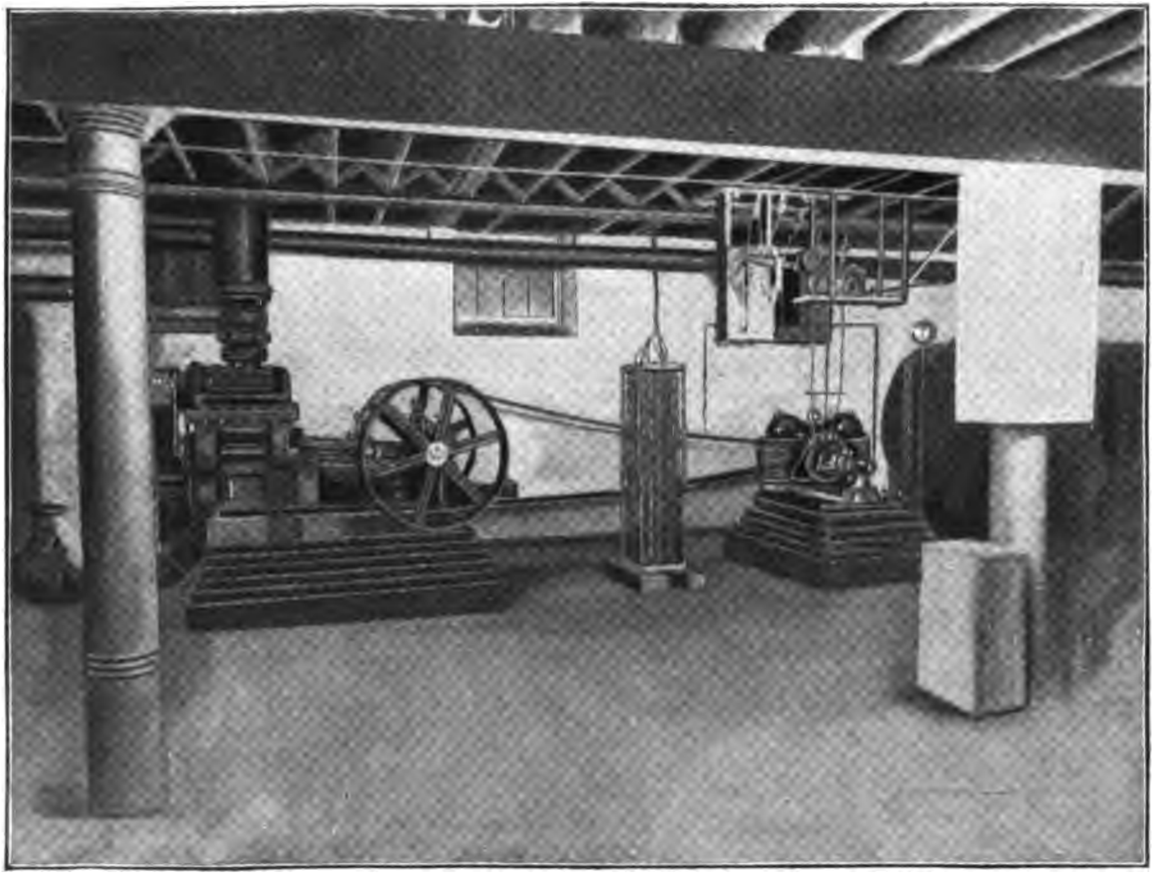
Carter, Rice & Co	Boston, Mass.
Leach, Annable & Co	Boston, Mass.
Batchelder & Lincoln	Boston, Mass.
A. Storrs & Bement Co	Boston, Mass.
Chas. Richardson & Co	Boston, Mass.
Abram French & Co	Boston, Mass.
Union Institution for Savings	Boston, Mass.
N. H. Emmons	Boston, Mass.
De L. Sheplie	Boston, Mass.
J. Remick	Boston, Mass.
Mrs. B. E. Hastings	Boston, Mass.
Allen Bros	Boston, Mass.
E. K. Harris	Boston, Mass.
Thompson, Witherill & Willis	Boston, Mass.
John Goldthwaite	Boston, Mass.
James T. Eldridge	Boston, Mass.
West End Street Railway, Bartlett Street Shops	Boston, Mass.
Heyer Bros	Boston, Mass.
Arthur, McArthur & Co	Boston, Mass.
John E. Cassidy	Boston, Mass.
John C. Haynes	Boston, Mass.
Kistler, Lesh & Co	Boston, Mass.
Jere Abbott	Boston, Mass.
Meredith & Nelson, Agts	Boston, Mass.
A. W. Anderson	Brockton, Mass.
J. S. Noyes & Co	Lawrence, Mass.
Pemberton Mills	Lawrence, Mass.
Pratt & Whitney	Hartford, Conn.
J. L. Morgan & Co	New York City
Boynton Furnace Co	New York City
Union Stove Works	New York City
G. G. Hallett	New York City
Simonds Manufacturing Co	New York City
Fred Adee	New York City
Palmer Manufacturing Co	New York City
Von Wagener & Co	New York City
Richardson & Boynton	New York City
R. Holliday's Sons	New York City
Herman Behr	New York City
Edinger Bros	New York City
W. H. B. Fotten	New York City



View of 3 Horse Power Motor in use at the Wholesale Grocery Store of Thurber, Whyland & Co., New York City. This Motor replaced the steam engine which is shown in the view and which is now abandoned. All the work formerly performed by the steam engine is now done by the Motor in a less expensive and more satisfactory way. The view shows very clearly the difference in space required by one of our Motors and a steam engine to do the same work.

(*Elevators continued.*)

G. T. Knight	New York City
F. W. Hunt & Son	New York City
Recamier Manufacturing Co	New York City
Pettet & Reed	New York City
Union Gas and Oil Stove Co	New York City
R. J. Maddell & Co	New York City
H. Bessen	New York City
R. D. Young	New York City
Jas. S. Barron & Co	New York City
Brown & Rittenhouse	New York City
R. H. Macy & Co	New York City
R. L. Cole	New York City
J. Robinson & Co	New York City
J. A. Smith & Bros	New York City
Roesler & Hasselor	New York City
Baeder, Adamson & Co	New York City
Smith & Sills	New York City
Parke, Davis & Co	New York City
Travers Bros	New York City
Lazell, Dalley & Co	New York City
Packer & James	New York City
White, Howard & Co	New York City
Perry Stove Works	New York City
Warner Bros	New York City
American News Co	New York City
H. Ramsdell	Newburgh, N. Y.
New York Furniture Co	Newburgh, N. Y.
Grant Edgar	Newburgh, N. Y.
Barnes & Mapes	Newburgh, N. Y.
United Security Trust & Safe Deposit Co	Philadelphia, Pa.
The Otis Elevator Co	Philadelphia, Pa.
Charles J. Cohen	Philadelphia, Pa.
Paul Bros	Philadelphia, Pa.
I. Lehman & Bro	Pittsburgh, Pa.
Jas. A. McNally	Pittsburgh, Pa.
J. B. Kendall	Washington, D. C.
W. H. Hoeke	Washington, D. C.
M. A. Story	Washington, D. C.
H. O. Towels	Washington, D. C.
A. McNally	Chicago, Ill.
Lyon & Healy	Chicago, Ill.
Midland Hotel	Chicago, Ill.
Phœnix Building	Chicago, Ill.
The Byran Block	Chicago, Ill.
B. F. DeMuth & Co	Chicago, Ill.
Lambert Tree Building	Chicago, Ill.
H. Stoekling	Elgin, Ill.
Ferguson & Herndon	Louisville, Ky.
H. & B. Beer	New Orleans, La.
Citizens' Bank	New Orleans, La.
E. Danziger	New Orleans, La.
Eugene Dupre	New Orleans, La.
Esther Warehouse	New Orleans, La.
Max Fraenkel	New Orleans, La.
Finlay & Brunswig	New Orleans, La.
Leon Godchaux	New Orleans, La.
Goldstein & Sons	New Orleans, La.
Hunter & Genslinger	New Orleans, La.



25 H. P. Motor operating Pump for Hydraulic Elevator at Wholesale Clothing House of Stein, Bloch & Co., Rochester, N. Y.

(*Elevators continued.*)

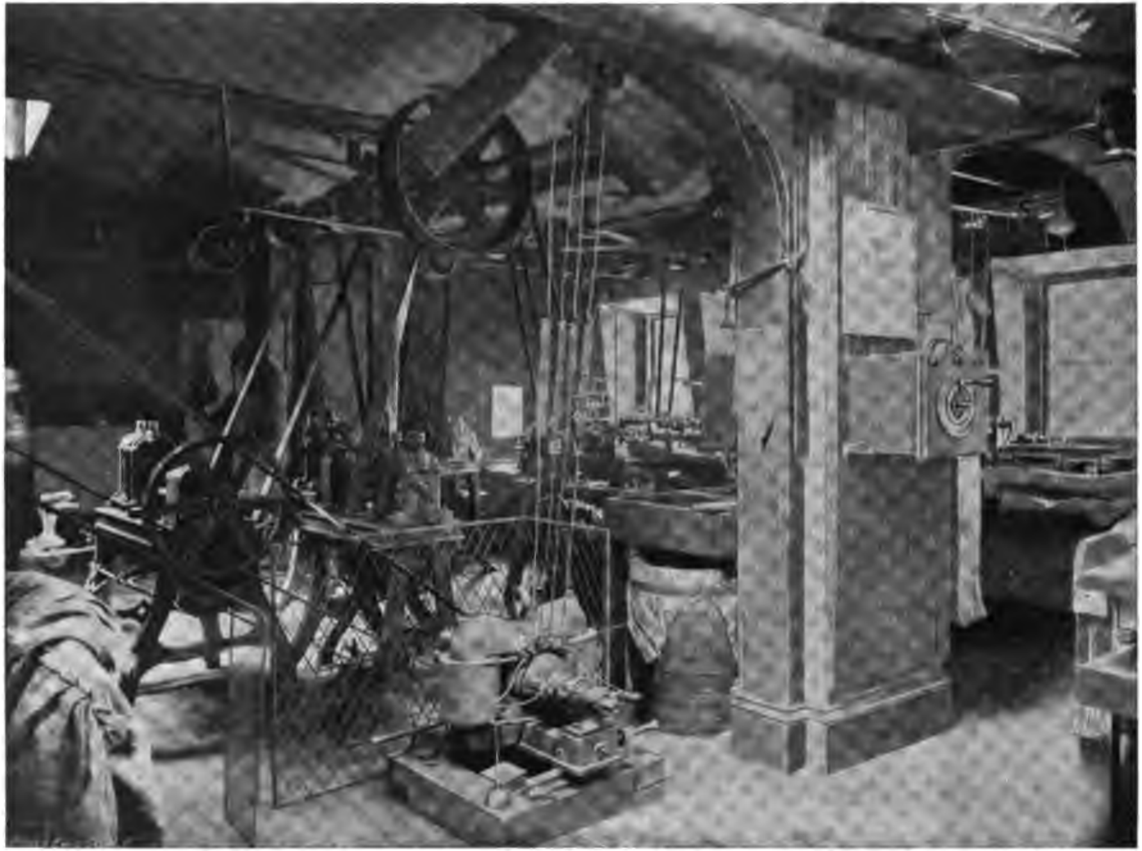
D. H. Holmes	New Orleans, La.
Holloway & Gardes	New Orleans, La.
Marquas & Co.	New Orleans, La.
Julius Meyer	New Orleans, La.
N. O. News Co.	New Orleans, La.
B. Rosenberg	New Orleans, La.
Red Star Shoe Store	New Orleans, La.
Daily States	New Orleans, La.
J. & M. Schwabacher	New Orleans, La.
Sugar Shed Co.	New Orleans, La.
Solari Building	New Orleans, La.
W. W. Washburn	New Orleans, La.
J. L. Hudson	Detroit, Mich.
Taylor, Woolfeuden & Co.	Detroit, Mich.
Detroit News Co.	Detroit, Mich.
Detroit Carpet & Furniture Co.	Detroit, Mich.
Detroit Metallic Casket Co.	Detroit, Mich.
McNaughton, Walker & Co.	Detroit, Mich.
Brown Bros.	Detroit, Mich.
Gamble Partridge	Detroit, Mich.
Edison Electric Ill. Co.	Detroit, Mich.
Doniphan & Co.	St. Joseph, Mo.
Central National Bank	Topeka, Kans.
W. C. Knox Bank	Topeka, Kans.
Kansas Farmer Building	Topeka, Kans.
Stevenson & Peckham	Topeka, Kans.
Bethany College	Topeka, Kans.
First National Bank Building	Topeka, Kans.
Dennis & Ewart	Topeka, Kans.
Sweet & Bulkley	Grand Rapids, Mich.
Walter A. Wood Manufacturing Co.	Minneapolis, Minn.
Fidelity Warehouse Co.	Minneapolis, Minn.
Crane Elevator Co.	Kansas City, Mo.
W. J. Kinsey Implement Co.	Denver, Colo.
Hotel Spokane	Spokane Falls, Washington
Holley, Mason, Marks & Co.	Spokane Falls, Washington
J. M. Coleman	Seattle, Washington

EXPERIMENTAL WORK, ETC.

Jno. Pondir & Co.	New York City
Columbia College	New York City
Prof. E. W. Morley (Adelbert College)	Cleveland, O.
J. B. Allen	Hutchinson, Kans.

HOISTS.

O. Hodgkins	Boston, Mass.
M. J. Goggin	Boston, Mass.
U. B. Campbell	Boston, Mass.
New England Electric Co.	Boston, Mass.
Fall River Bleachery	Fall River, Mass.
U. S. S. "Atlanta"	Washington, D. C.
Edison Electric Illuminating Co.	Chicago, Ill.
Phœnix Building	Chicago, Ill.
The Aspen Mining & Smelting Co.	Aspen, Colo.
The Regent Mine	Aspen, Colo.
The Aspen Mine	Aspen, Colo.
Taylor & Brunton	Aspen, Colo.
G. H. Evans	Topeka, Kans.
Fire Proof Construction Co.	Topeka, Kans.



View of 5 Horse Power Motor, operating Manufacturing Jewellers' Machinery at the shop of Roberts & Foster, 46 School Street, Boston.

ICE CREAM FREEZERS.

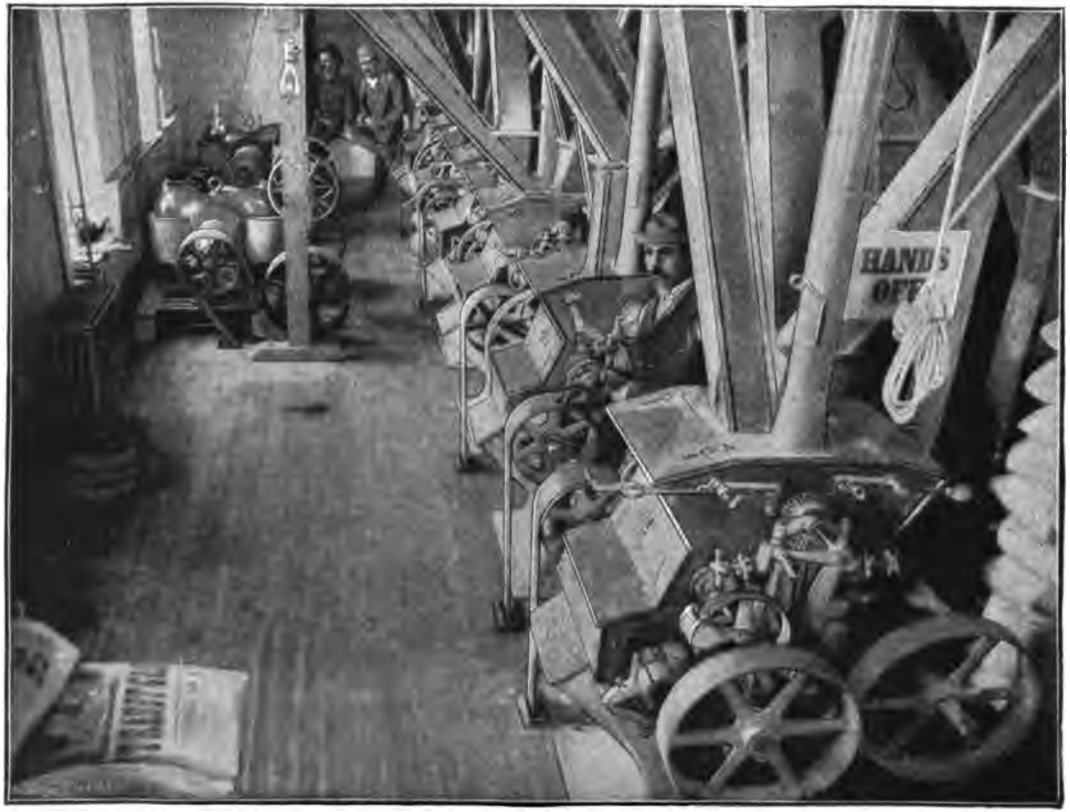
H. P. Vieth	Boston, Mass.
P. & J. Besse	Boston, Mass.
Albert Weidman	Lawrence, Mass.
George F. Talbot	Lawrence, Mass.
Winslow & Vogel	Fall River, Mass.
H. C. Ewald	Washington, D. C.
Schramer Bros	Elgin, Ills.
John T. Shaw	New Orleans, La.
J. C. Hopkins	Topeka, Kans.

JEWELERS' AND OPTICIANS' MACHINERY.

Bigelow & Kennard	Boston, Mass.
M. H. Downes	Boston, Mass.
Robert & Foster	Boston, Mass.
Norling & Bloom	Boston, Mass.
L. Newman	New York City
M. Fox	New York City
H. Lehr	New York City
J. N. Provenzano	New York City
A. J. Groveman	New York City
Lehr & Locks	New York City
E. Newton	New York City
Brandes Manufacturing Co	New York City
Heller & Bardell	New York City
M. B. Bryant	New York City
Chris. Blanchard	New York City
Gorham Manufacturing Co	New York City
O. O. Stillman	New Brunswick, N. J.
Borsch & Rommel	Philadelphia, Pa.
Franz Frederick	Washington, D. C.
George Wolf & Co	Louisville, Ky.
Roehm & Son	Detroit, Mich.
Wright, Kay & Co	Detroit, Mich.
Doniphan & Co	Kansas City, Mo.
A. J. Stark	Denver, Colo.

LATHES.

Albert Anderson	Boston, Mass.
Wheeler & Wilson	Boston, Mass.
L. J. McIntyre	Boston, Mass.
S. H. Ailman	Boston, Mass.
G. H. Lloyd	Boston, Mass.
Bigelow & Kennard	Boston, Mass.
M. H. Downes	Boston, Mass.
John H. Hillman	Boston, Mass.
New England Electric Co	Boston, Mass.
F. L. Pope	Providence, R. I.
Woonsocket Machine and Power Co	Woonsocket, R. I.
Telephone Exchange	Fall River, Mass.
Gorham Manufacturing Co	New York City
Brandes Manufacturing Co	New York City
Chr. Blanchard	New York City
Saratoga Gas & Electric Light Co	Saratoga, N. Y.
George F. Pillings' Sons	Philadelphia, Pa.
H. T. Paiste	Philadelphia, Pa.
Ourdan & Klob	Washington, D. C.



Interior view of the Roller floor of the Laramie Milling and Elevator Company's Flouring Mill, Wyoming, operated by Edison Motors.

(*Lathes continued.*)

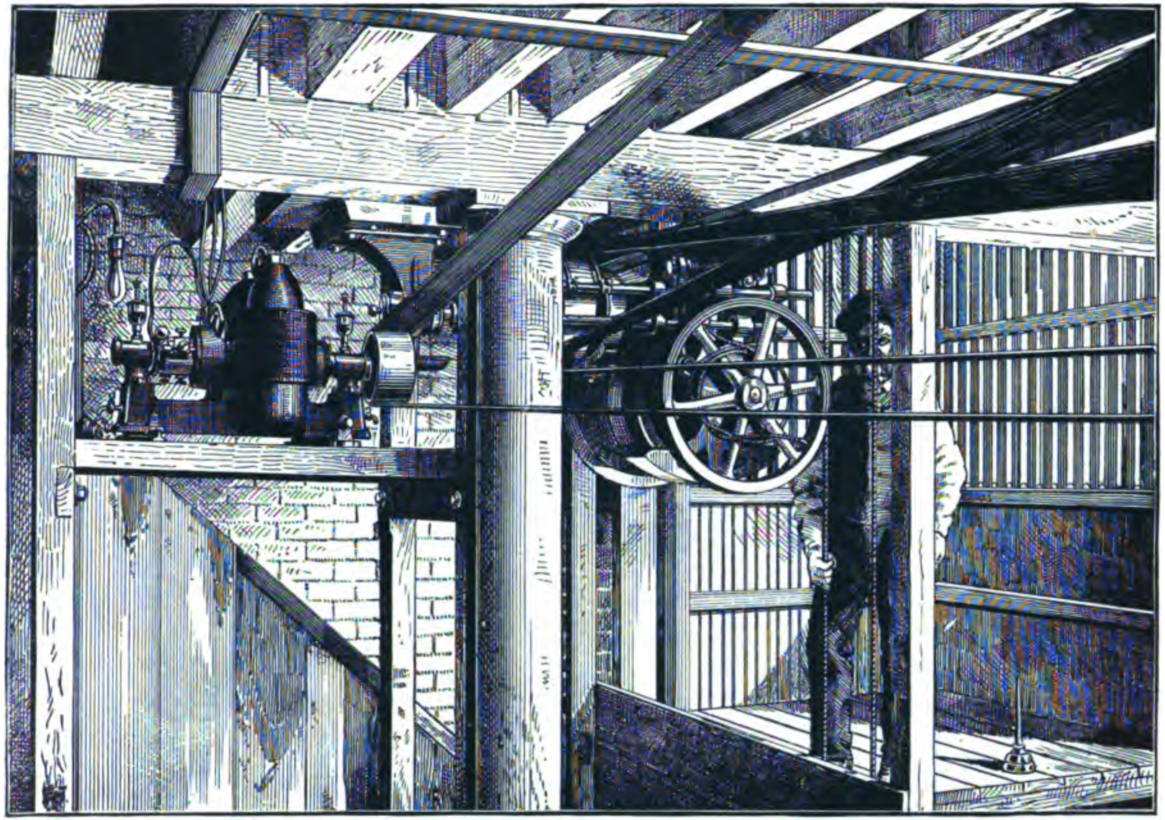
Franz Fredinck	Washington, D. C.
Wm. Oswald	New Orleans, La.
Jos. Menge	New Orleans, La.
Wm. Trowbridge	New Orleans, La.
Hibbard, Spencer & Bro	Chicago, Ill.
Municipal Fire Department	Chicago, Ill.
The M. C. Lilley Co	Columbus, O.
Columbus Closet Co	Columbus, O.
L. Black & Co	Detroit, Mich.
A. J. Stark	Denver, Colo.

LAUNDRY MACHINERY.

Geo. Frost & Co	Boston, Mass.
Gourlay Bros	Detroit, Mich.

MACHINE SHOPS AND MISCELLANEOUS MACHINERY.

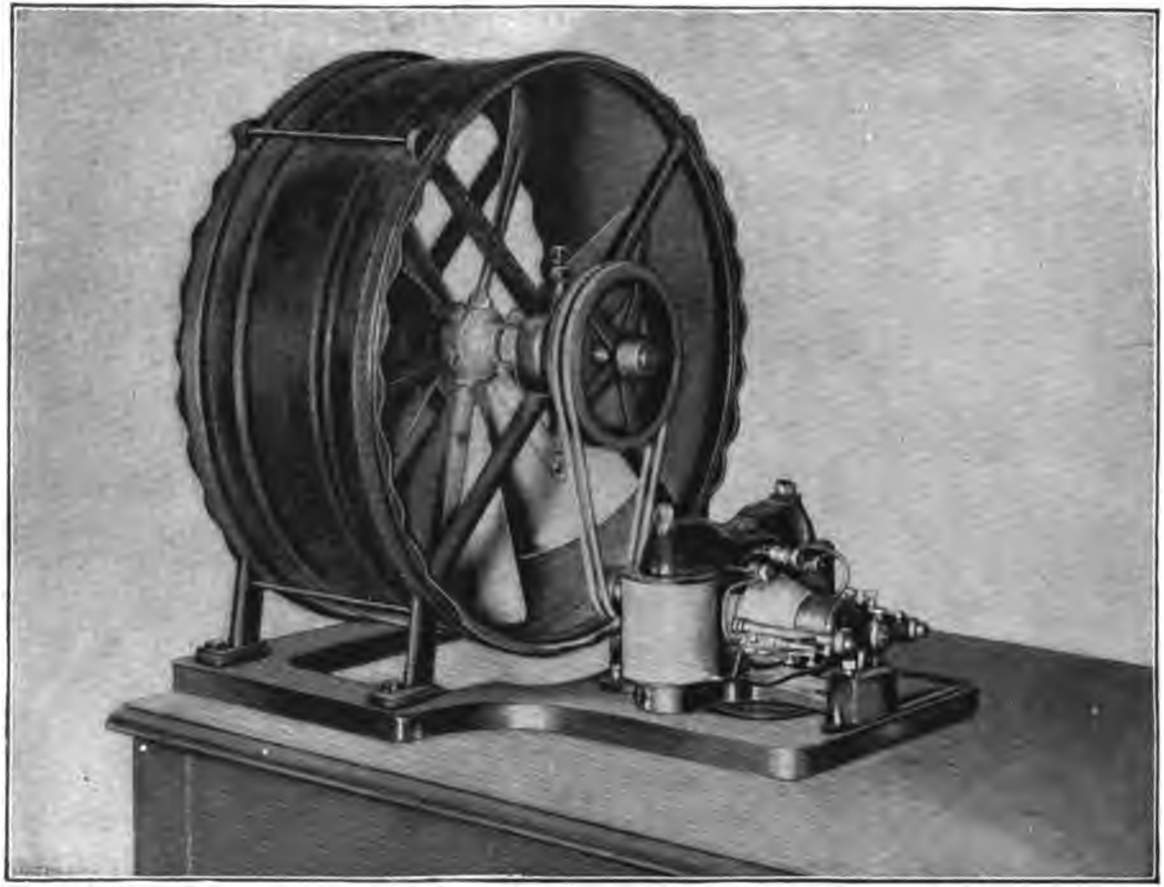
John Becker	Boston, Mass.
D. Wittemore	Boston, Mass.
Albert Anderson	Boston, Mass.
Wheeler & Wilson	Boston, Mass.
H. McShane	Boston, Mass.
Seth Burrill & Son	Boston, Mass.
A. L. Mariner & Co	Boston, Mass.
West End St. Ry. Co., Bartlett St. Shops	Boston, Mass.
West End St. Ry. Co., Allston	Boston, Mass.
City of Boston Police Department	Boston, Mass.
John Tein	Boston, Mass.
John H. Hollman	Boston, Mass.
The Gould & Watson Co	Boston, Mass.
New England Electric Co	Boston, Mass.
Eastern Block Co	Boston, Mass.
A. E. Rowe	Boston, Mass.
M. J. Goggin	Boston, Mass.
U. B. Campbell	Boston, Mass.
American Health & Supply Co	Boston, Mass.
Dinsmore Mfg. Co	Boston, Mass.
Sherman Electric Storage Equipment Co	Boston, Mass.
Geo. Frost & Co	Boston, Mass.
Excelsior Button Hole Co	Boston, Mass.
Boston Button Hole Co	Boston, Mass.
Morley Shoe Button Co	Boston, Mass.
Otis Clapp & Son	Boston, Mass.
E. M. Low	Brockton, Mass.
R. G. Sheppard	Brockton, Mass.
W. C. Lawrence	Brockton, Mass.
Woonsocket Machine & Power Co	Woonsocket, R. I.
F. L. Pope	Providence, R. I.
Pawtucket Gas Co	Pawtucket, R. I.
T. J. McLeod	New York City
N. Y. Leather Findings Co	New York City
Armeny & Marion	New York City
Lazal, Dully & Co	New York City
C. G. Braumar	New York City
P. Dauphine	New York City
Cont. Press	New York City
E. Eicke	New York City



This Motor is of 7½ H. P., and operates a Freight Elevator. It is in use at the Boynton Furnace Co., 209 Water Street, New York.

(*Machine Shops and Miscellaneous Machinery continued.*)

Recamier Manufacturing Co.	New York City
H. Rosenthal	New York City
F. W. Hunt & Son	New York City
Von Lengerke & Detnold	New York City
Geo. E. Hall	New York City
Wykoff, Seamens & Benedict	New York City
C. R. Flemming	New York City
Von Wagoner & Co.	New York City
Chas. Hubbs	New York City
Leggett Bros.	New York City
James H. Dotzert	Newburgh, N. Y.
Alfred Dodge	Dolgeville, N. Y.
Waterloo Electric Co.	Waterloo, N. Y.
Saratoga Gas & Electric Light Co.	Saratoga, N. Y.
James Arnold	Philadelphia, Pa.
Borsh & Rommel	Philadelphia, Pa.
John Parker Manufacturing Co.	Philadelphia, Pa.
H. T. Paiste	Philadelphia, Pa.
Wm. M. Speakman	Philadelphia, Pa.
Keystone Watch Club Co.	Philadelphia, Pa.
Wright, Ayer & Co.	Philadelphia, Pa.
J. L. Stadelman	Ardmore, Pa.
Camden & Atlantic R. R. Co.	Atlantic City, N. J.
Edgemoor Bridge Works	Edgemoor, Del.
F. H. Finley	Washington, D. C.
Marvin C. Stone	Washington, D. C.
Durdan & Kolb	Washington, D. C.
Lanston Type & Type Machine Co.	Washington, D. C.
Edw. P. Mertz	Washington, D. C.
U. S. Treasury Department, Registers Division	Washington, D. C.
Gulf Manufacturing Co.	New Orleans, La.
Gulf Spring Bed Manufacturing Co.	New Orleans, La.
H. Haller Manufacturing Co.	New Orleans, La.
Louisiana Mattress Co.	New Orleans, La.
Eugene May	New Orleans, La.
Manion & Co.	New Orleans, La.
Jos. Menge	New Orleans, La.
Chas. G. Schultz	New Orleans, La.
Wm. Trowbridge	New Orleans, La.
Municipal Fire Department	Chicago, Ill.
Hibbard, Spencer & Co.	Chicago, Ill.
C. N. Nelson	Chicago, Ill.
R. Peters	Chicago, Ill.
F. G. Jungblut & Co.	Chicago, Ill.
Pumhard Dow	Elgin, Ill.
Kohn & Alull	Elgin, Ill.
J. F. Selbybridge	Elgin, Ill.
Schroeder Meat Cutter Co.	Elgin, Ill.
P. Selbybridge	Elgin, Ill.
Central Ohio Paper Co.	Columbus, O.
M. C. Lilley	Columbus, O.
J. H. and F. A. Sells	Columbus, O.
East Cleveland Street Ry. Co. Shops	Cleveland, O.
Augustus Day	Detroit, Mich.
Western Knitting Co.	Detroit. Mich.
Automatic Cigar Seller Co.	Detroit, Mich.
Edison Electric Ill. Co.	Grand Rapids, Mich.
Weatherly & Putte	Grand Rapids, Mich.



View of ¼ H. P. Combination Motor and Fan.

(*Machine Shops and Miscellaneous Machinery continued.*)

A. Woods, Carriage Builder	Grand Rapids, Mich.
Grand Rapids Telephone Exchange	Grand Rapids, Mich.
J. K. Bortree Manufacturing Co	Grand Rapids, Mich.
Parker & Green	Grand Rapids, Mich.
Rwid & Co	Jackson, Mich.
Gaynor Electric Co	Louisville, Ky.
Fergurson & Herndon	Louisville, Ky.
Morton Bros	Louisville, Ky.
Hetterman Bros	Louisville, Ky.
Dodson, Fisher & Brockman	Minneapolis, Minn.
Edison Light and Power Co	Minneapolis, Minn.
G. W. Crane & Co., Bookbinder	Topeka, Kans.
W. P. Emery	Topeka, Kans.
Carpet Cleaning Works	Topeka, Kans.
A. B. Perine	Topeka, Kans.
C. Lindenschmidt	Topeka, Kans.
Smith Manufacturing Co	Topeka, Kans.
Heckel Bros	Kansas City, Mo.
C. W. Siemans	Kansas City, Mo.
Geo. Meyer	Kansas City, Mo.
Kearney Canning Co	Kearney, Neb.
West Kearney Woolen Mill	Kearney, Neb.
Kearney Paper Co	Kearney, Neb.
Kearney Brick Co	Kearney, Neb.
Laramie Milling and Elevator Co	Laramie, Wyo.
Laramie Rolling Mill	Laramie, Wyo.
Craffey & Crowel	Denver, Colo.
A. J. Stark	Denver, Colo.
Oregon City Electric Light Co	Portland, Ore.
Dominion Electric Manufacturing Co	Montreal, Can.
Messrs. Paterson & Corbett	St. Catherines, Ont.

MEAT CUTTERS.

W. H. Marshall	Newburgh, N. Y.
Henry H. Baker	Newburgh, N. Y.
Schroeder Meat Cutter Co	Elgin, Ill.
P. Selbybridge	Elgin, Ill.
Kohn & Alull	Elgin, Ill.
J. F. Selbybridge	Elgin, Ill.

MODELS.

Sherman Electric Storage Equipment Co	Boston, Mass.
Jno. A. Pondir	New York City.

ORGANS.

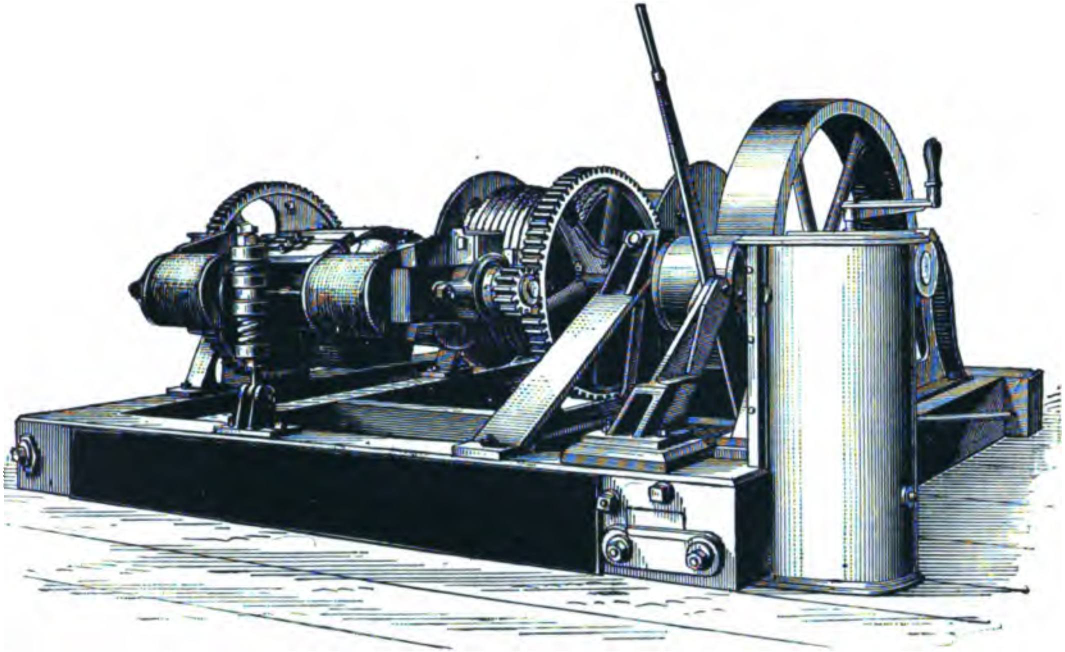
Tabernacle Baptist Church	Philadelphia, Pa.
C. W. Kennedy & Co	Philadelphia, Pa.
Plymouth Church	Des Moines, Ia.

PAPER AND CLOTH CUTTERS.

Chas. Hubbs	New York City
Rose & Cohen	New York City
James Arnold	Philadelphia, Pa.
Central Ohio Paper Co	Columbus, O.
G. W. Crane & Co	Topeka, Kans.

PHOTOGRAPH BURNISHERS.

Notman Photograph Co	Boston, Mass.
Elmer Chickering	Boston, Mass.



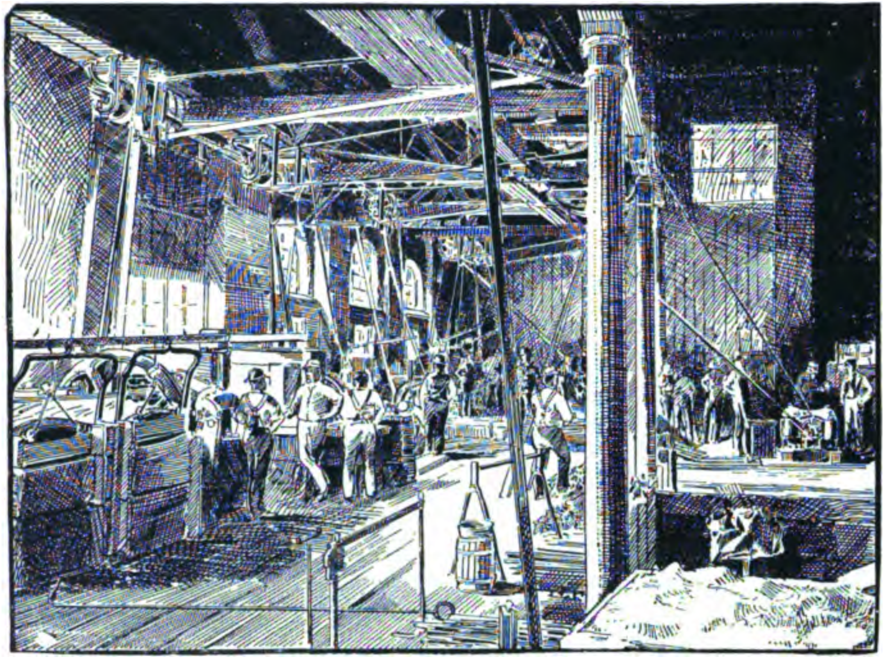
Incline-Hoist used in Mines at Aspen, Colorado, operated by 10 Horse Power Motor.

PNEUMATIC TUBES.

Western Union Tel. Co.	Columbus, O.
John A. Pondir	New York City

PRINTING PRESSES.

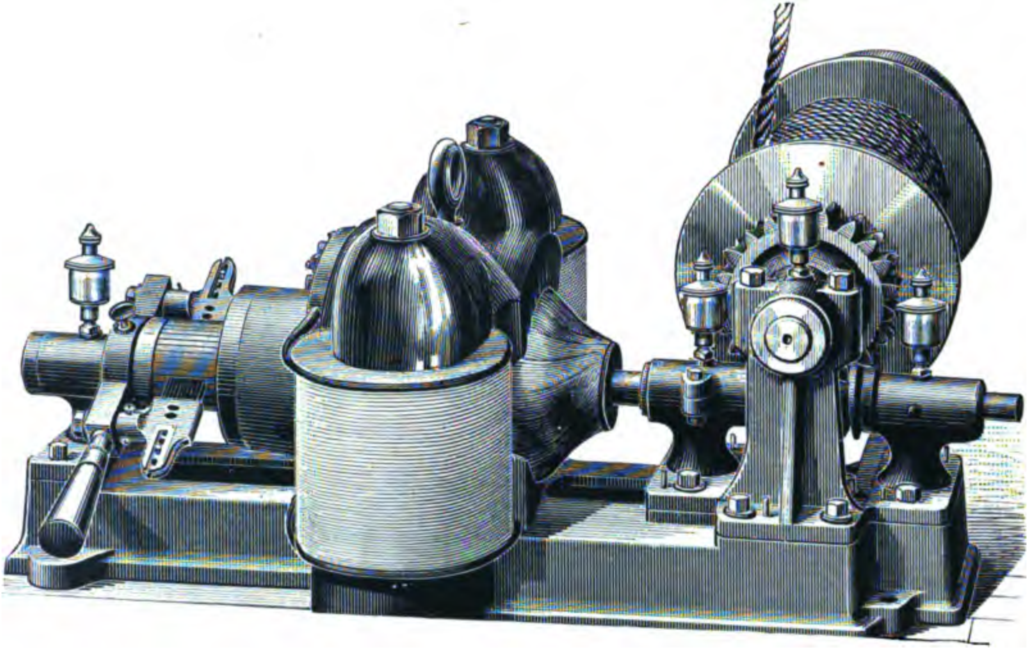
C. H. Hintzman	Boston, Mass.
L. E. Cowles & Co	Boston, Mass.
Boston Bank Note & Lithograph Co	Boston, Mass.
C. H. Woodman	Boston, Mass.
Atlantic & Pacific Tea Co	Boston, Mass.
A. C. Getchell	Boston, Mass.
Robertson & Stephens	Boston, Mass.
C. H. Simonds & Co	Boston, Mass.
Albert Hallett	Boston, Mass.
Charles W. Bascom	Boston, Mass.
Boston News Bureau	Boston, Mass.
C. S. Oberman, Grocers, Canners & Packers Publishing Co.	Boston, Mass.
Herald Publishing Co	Boston, Mass.
George B. Wilcox	Boston, Mass.
McDonald, Gill & Co	Boston, Mass.
Brooks Lithographic Co	Boston, Mass.
F. S. Tolman	Brockton, Mass.
Enterprise Publishing Co	Brockton, Mass.
A. M. Bridgeman	Brockton, Mass.
Eaton V. Read	Brockton, Mass.
Hugo E. Dick	Lawrence, Mass.
Milford Daily News	Milford, Mass.
J. H. Franklin	Fall River, Mass.
C. A. W. Spencer	Brookline, Mass.
W. C. Martin	New York City
Van den Houten & Co.	New York City
Shipman & Peniston	New York City
Thurber, Wyland & Co	New York City
A. D. Smith	New York City
E. W. Ruttenbeer	Newburgh, N. Y.
Albert C. Goodwin	Albany, N. Y.
Walker & Thomas	Jamestown, N. Y.
W. Armitage & Co	Newark, N. J.
W. A. Baker	Newark, N. J.
Home News	New Brunswick, N. J.
Hugh Boyd	New Brunswick, N. J.
" Philadelphia Press "	Philadelphia, Pa.
American Bank Note Co	Philadelphia, Pa.
Richwine Bros	Philadelphia, Pa.
H. J. R. Toye	Philadelphia, Pa.
Oliver Braden	Philadelphia, Pa.
Jos. Coombs	Philadelphia, Pa.
Bennage & Elliott	Philadelphia, Pa.
Postel & Gilbee	Philadelphia, Pa.
Stevenson & Foster	Pittsburgh, Pa.
H. J. Rothrock	Washington, D. C.
E. W. Fox, " Washington Press "	Washington, D. C.
J. H. Soute	Washington, D. C.
W. H. Lepley	Washington, D. C.
J. T. Mitchell	Washington, D. C.
Anson S. Taylor	Washington, D. C.
Adjutant General Office, War Department	Washington, D. C.



Rolling Mill at Laramie, Wyoming, operated by an Edison Electric Motor.

(*Printing Presses continued.*)

Jos. L. Pearson	Washington, D. C.
Benj. F. Wilkins, Jr.	Washington, D. C.
Radcliffe & Manny	Chicago, Ill.
H. O. Shepard	Chicago, Ill.
"Chicago Tribune"	Chicago, Ill.
J. Anthony	Chicago, Ill.
Elgin News Printing Co.	Elgin, Ill.
N. P. Tucker	Elgin, Ill.
C. Van Gooder	Elgin, Ill.
J. J. Ashenhurst	Canton, O.
Central Press Association Co.	Columbus, O.
Nitsshler Brothers	Columbus, O.
Gazette Printing House	Columbus, O.
Hibbard Rheumatic Syrup Co.	Jackson, Mich.
Hunt & Bridgeman Printing Co.	Jackson, Mich.
Kerby Printing Co.	Detroit, Mich.
"The Detroit Tribune"	Detroit, Mich.
West Michigan Tribune Co.	Grand Rapids, Mich.
Deane Printing Co.	Grand Rapids, Mich.
I. S. Dygert	Grand Rapids, Mich.
Minnesota "Tribune" Co.	Minneapolis, Minn.
"Tribune" Job Printing Co.	Minneapolis, Minn.
Alfred Roper	Minneapolis, Minn.
Periodical Press Co.	Minneapolis, Minn.
E. A. Brandao	New Orleans, La.
J. B. Cameron	New Orleans, La.
Hunter & Genslinger	New Orleans, La.
D. Hollander	New Orleans, La.
"Daily News"	New Orleans, La.
J. E. Pendergast	New Orleans, La.
"Daily States"	New Orleans, La.
"Times-Democrat"	New Orleans, La.
Roberts & Son	Birmingham, Ala.
"The Evening Chronicle"	Birmingham, Ala.
"The Alabama Christian Advocate"	Birmingham, Ala.
Diamond Printer	Kansas City, Mo.
"Daily Capital"	Topeka, Kans.
"State Journal"	Topeka, Kans.
"Topeka Democrat"	Topeka, Kans.
Hall & O'Donald	Topeka, Kans.
C. B. Hamilton	Topeka, Kans.
Reed-Martin Printing Co.	Topeka, Kans.
I. H. Holt	Topeka, Kans.
C. Spaulding	Topeka, Kans.
L. H. Evart	Topeka, Kans.
A., T. & S. F. R. R.	Topeka, Kans.
"Hutchinson Daily News"	Hutchinson, Kans.
"Abilene Gazette"	Abilene, Kans.
"Salina Republican"	Salina, Kans.
"Iowa State Register"	Des Moines, Ia.
"The Kearney Enterprise"	Kearney, Neb.
Hub Printing Co.	Kearney, Neb.
"The Daily Journal"	Kearney, Neb.
Rhone Bros.	Kearney, Neb.
Denver Lithograph Co.	Denver, Colo.
W. D. Knight, "Daily Chronicle"	Spokane Falls, Washington
Spokane Printing Co., Daily Newspaper Press,	Spokane Falls, Washington
Loman & Hanford	Seattle, Washington



View of 3 H. P. Electric Hoist, in use on U. S. S. "Atlanta" for hoisting shell.

(*Printing Presses continued.*)

Koch & Oakley	Seattle, Washington
W. B. Bailey	Seattle, Washington
B. B. Dearborn	Seattle, Washington
"News-Advertiser"	Vancouver, British Columbia
Globe Printing Co	Toronto, Can.

PUMPS.

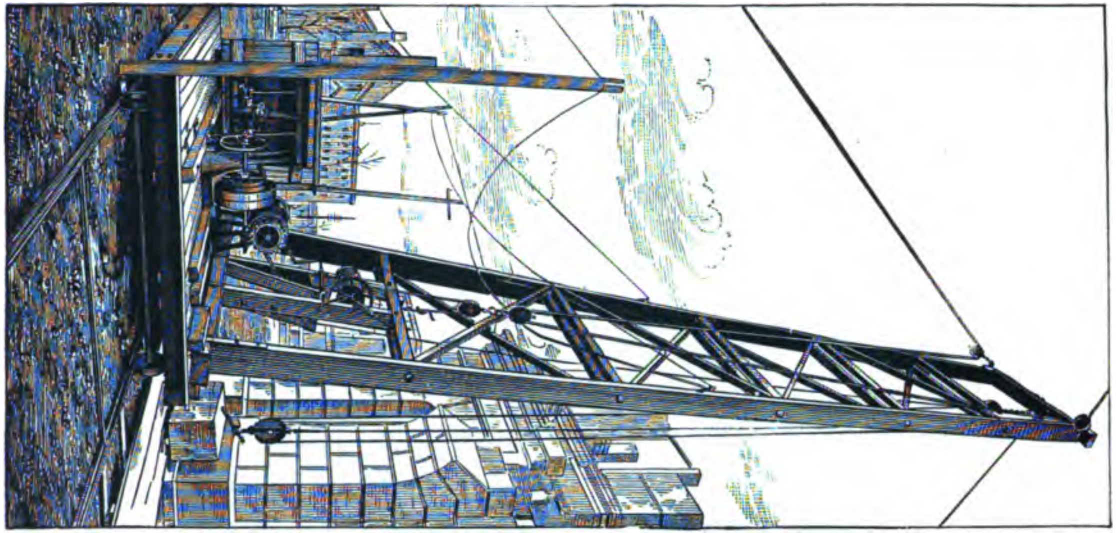
Mrs. B. E. Hastings	Boston, Mass.
Suffolk Brewing Co	South Boston, Mass.
E. H. Johnson	Greenwich, Conn.
Strasberger & Co	New York City
C. H. Coster	New York City
Osgood Welsh	New York City
W. J. Johnston	New York City
Whitelaw Reid	White Plains, N. Y.
Stein, Bloch & Co	Rochester, N. Y.
Dr. Ray V. Pierce	Buffalo, N. Y.
United Security Trust and Safe Deposit Co	Philadelphia, Pa.
H. & B. Beer	New Orleans, La.
Citizens' Bank	New Orleans, La.
Solari Building	New Orleans, La.
A. McNally	Chicago, Ill.
Lyon & Healy	Chicago, Ill.
Midland Hotel	Chicago, Ill.
Hibbard Rheumatic Syrup Co	Jackson, Mich.
Kleinhaus & Simonson	Louisville, Ky.
T. J. Hay	Spokane Falls, Washington
Hotel Spokane	Spokane Falls, Washington
J. M. Coleman	Seattle, Washington

SAUSAGE MACHINES.

O. B. Lewis	New Bedford, Mass.
E. C. Bronnell	New Bedford, Mass.
Matthew Daly	New Brunswick, N. J.
Geo. Blair	New Brunswick, N. J.
John Deinzer	New Brunswick, N. J.

SEWING MACHINES.

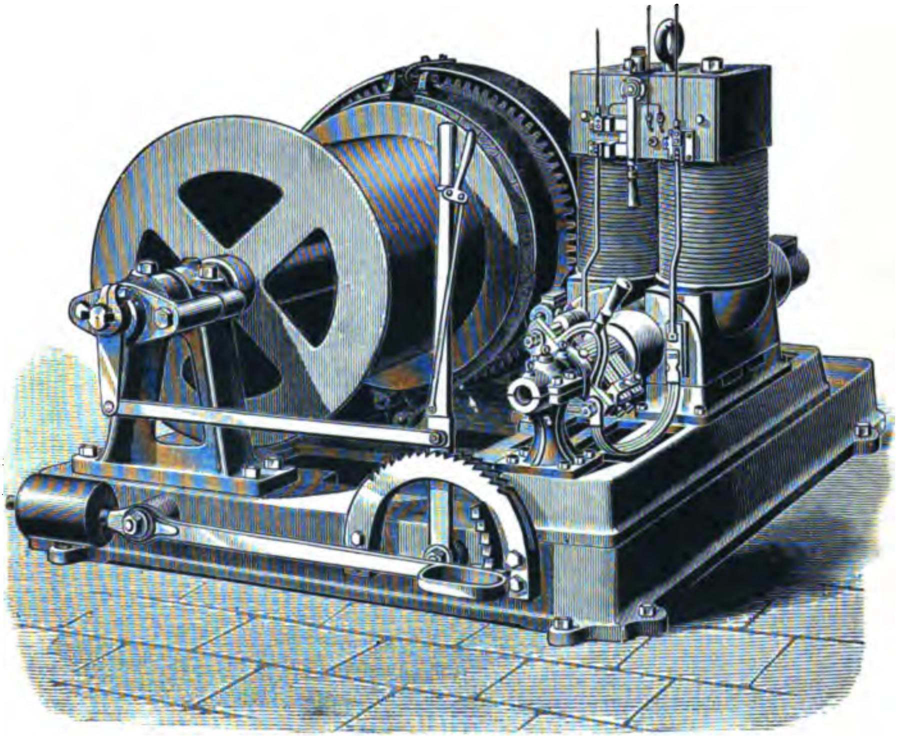
J. R. Farrell	Boston, Mass.
Aaron Slutski	Boston, Mass.
C. H. Farmer	Boston, Mass.
J. L. Symonds	Boston, Mass.
P. Lozowoski	Boston, Mass.
Plymouth Rock Pants Co	Boston, Mass.
J. Peavy & Bros	Boston, Mass.
Henry Hollander	Boston, Mass.
Maurice Asher	Boston, Mass.
A. H. Sawtelle	Boston, Mass.
Wm. B. Carter	Boston, Mass.
Myers & Andrews	Boston, Mass.
Temple Manufacturing Co	Boston, Mass
Day, Callahan & Co	Boston, Mass.
Roberts & Ball	Boston, Mass.
Leventall, Watchmaker & Co	Boston, Mass.
C. A. Thomas	Boston, Mass.
Chester Manufacturing Co	Boston, Mass.



This cut shows one of the Hoisting Cranes used in the building of the new State Capitol, at Topeka, Kansas, and operated by Edison Motor. Stones of eight tons weight are easily handled and lifted to any height required.

(*Sewing Machines continued.*)

G. Cohen	Boston, Mass.
Liebe Friend	Boston, Mass.
L. Snider	Boston, Mass.
D. Harris Green	Boston, Mass.
Kaufman Baum	Boston, Mass.
Morris Levine & Co	Boston, Mass.
Gutman Bros	Boston, Mass.
N. Solomon	Boston, Mass.
Isaac L. King	Boston, Mass.
G. F. Pond	Boston, Mass.
H. Bright & Co	Boston, Mass.
George H. Lovejoy	Boston, Mass.
E. Nuremburg	Boston, Mass.
Isaac H. Dinner	Boston, Mass.
Stoughton Rubber Co	Boston, Mass.
George Frost & Co	Boston, Mass.
A. O. Very	Boston, Mass.
Boston Elastic Stocking Co	Boston, Mass.
L. Sheinwald	Boston, Mass.
M. Dean & Co	Boston, Mass.
Freeland, Loomis & Co	Boston, Mass.
Excelsior Umbrella Manufacturing Co	Boston, Mass.
William O'Brien	Boston, Mass.
Louis Gaetin	Boston, Mass.
D. Nurenburg & Son	Boston, Mass.
I. Bash & Son	Boston, Mass.
Marks & Abram	Boston, Mass.
M. Rosenfeld	Boston, Mass.
N. Tobias	Boston, Mass.
Richardson, Howe & Lovejoy	Boston, Mass.
Dover Clothing Co	Dover, N. H.
Paul Gumbinner	New York City
Rose & Cohen	New York City
M. G. Cohen	New York City
R. H. Macy & Co	New York City
H. S. Brown	New York City
Phœnix Jersey Works	New York City
Brokaw Manufacturing Co	Newburgh, N. Y.
Storm King Pants Co	Newburgh, N. Y.
Queen City Underwear Co	Buffalo, N. Y.
Barnes, Hegerer & Co	Buffalo, N. Y.
S. Brunner	New Orleans, La.
Joseph Cohn	New Orleans, La.
Max Fraekel	New Orleans, La.
Imperial Manufacturing Co	New Orleans, La.
Moses Lobe & Son	New Orleans, La.
W. F. T. Moir	New Orleans, La.
G. H. Magee	New Orleans, La.
S. R. Perry	New Orleans, La.
Rienach & Co	New Orleans, La.
B. J. Wolf & Sons	New Orleans, La.
Purski, Nick & Co	New Orleans, La.
Chas. L. Pitcher	New Orleans, La.
Picard, Kaiser & Co	New Orleans, La.
Rosenheim & Mauche	Cleveland, O.
John Anisfield & Co	Cleveland, O.
J. H. & F. S. Lens, Harness Makers	Columbus, O.
L. Heilprin & Co.	Chicago, Ill.



Edison Electric Hoist.

(*Sewing Machines continued.*)

Western Knitting Co	Detroit, Mich.
Reliance Corset Co	Jackson, Mich.
J. K. Bortree Manufacturing Co	Grand Rapids, Mich.
Michigan Overall Manufacturing Co	Grand Rapids, Mich.
C. J. Baker	Kansas City, Mo.
Custom Shirt Co	Louisville, Ky.

SUGAR REFINERY TRAMWAYS.

East Boston Sugar Refinery	East Boston, Mass.
California Sugar Refinery	San Francisco, Cal.

TRANSFER TABLES.

New York Central & Hudson River R. R. Co	New York City
Pennsylvania Railroad Co	Altoona, Pa.
Philadelphia & Reading Railroad Co	Reading, Pa.
Chicago, Burlington & Quincy R. R. Co	Aurora, Ill.
Wisconsin Central R. R. Co	Waukeeshaw, Wis.
West Bay City Industrial Works	West Bay City, Mich.

TRAVELING CRANES.

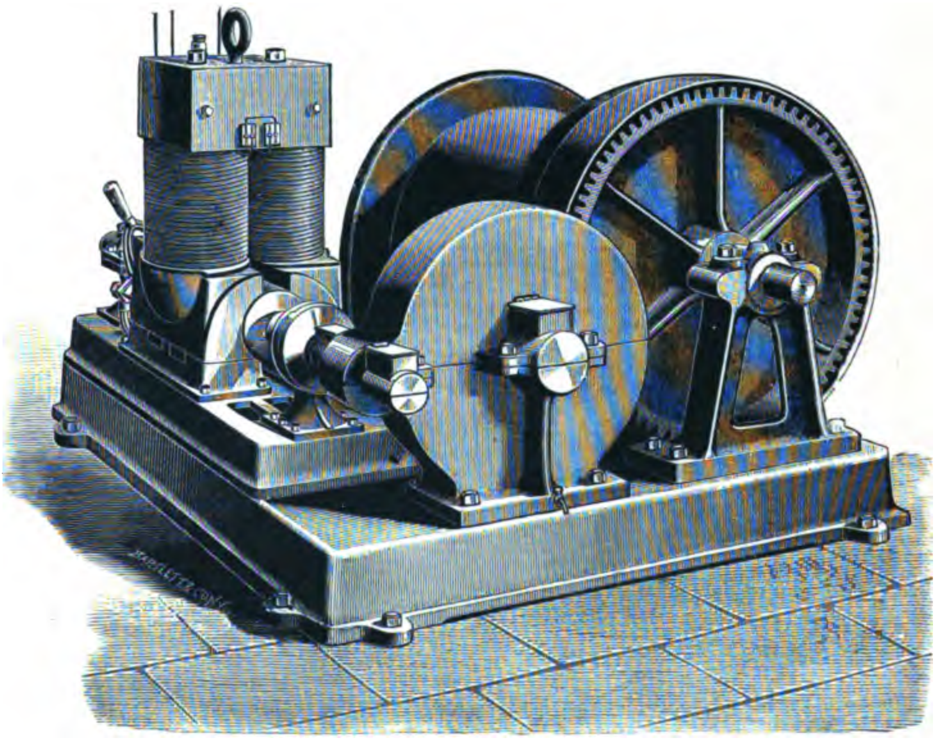
Wm. Sellers & Co., Machine Tool Builders	Philadelphia, Pa.
Southwark Foundry & Machine Co	Philadelphia, Pa.
Pennsylvania Railroad Co	Altoona, Pa.
E. P. Allis & Co., Reliance Works	Milwaukee, Wis.

TIN MACHINERY.

M. J. Goggin	Boston, Mass.
N. B. Campbell	Boston, Mass.
J. M. Bean	Boston, Mass.
H. Haller Manufacturing Co	New Orleans, La.

VENTILATORS.

George Francis	Boston, Mass.
Adams House	Boston, Mass.
Edison Electric Ill. Co	Boston, Mass.
H. P. Vieth	Boston, Mass.
Old Elm Restaurant	Boston, Mass.
Open Board Stock Exchange	Boston, Mass.
J. Tyler Hicks	Boston, Mass.
J. G. Cooper	Boston, Mass.
Russell & Sturgis	Boston, Mass.
C. R. Woods	Boston, Mass.
Shawmut National Bank	Boston, Mass.
T. D. Cook	Boston, Mass.
Edison Electric Ill. Co	Boston, Mass.
Oak Grove Farm	Boston, Mass.
Edison Electric Ill. Co	Fall River, Mass.
Edison Electric Ill. Co	Newport, R. I.
Drexel, Morgan & Co	New York City
Unger & Smithers	New York City
P. Van Evern	New York City
Carter, Sloane & Co	New York City
F. Eberlein	New York City
Seymour, Baker & Co	New York City
Jones, Kennet & Co	New York City
Edison Ill. Co	New York City



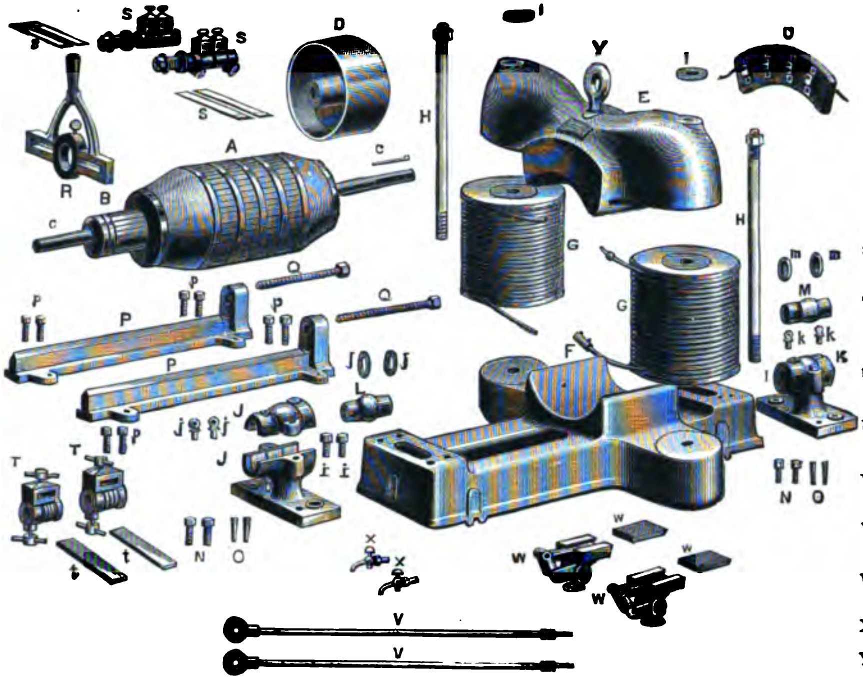
Edison Electric Hoist.

(*Ventilators continued.*)

W. J. Johnston	New York City
Park Bank	New York City
Rose & Cohen	New York City
J. Scheusch	New York City
M. Moquin	New York City
Gallatin Bank	New York City
Western National Bank	New York City
S. F. Meyers & Co	New York City
New York Stock Exchange	New York City
Western Union Telegraph Co	New York City
Bank of State of New York	New York City
Lord & Taylor	New York City
Aitken, Son & Co	New York City
H. L. Horton & Co	New York City
Third National Bank	New York City
W. Proctor	New York City
Blake Bros	New York City
Vermilye & Co	New York City
New York Exhaust Ventilator Co	New York City
S. M. Robins	New York City
E. A. Neirsheimer	New York City
E. H. Johnson	New York City
S. M. Swenson	New York City
Arion Club	New York City
S. F. Meyers & Co	New York City
Gold & Stock Telegraph Co	New York City
Lyceum Theatre	New York City
Union Square Theatre	New York City
F. Wilson	New York City
M. Michaels	New York City
German American Insurance Co	New York City
Fall River Line, Str. "Puritan"	New York City
Fall River Line, Str. "Pilgrim"	New York City
Solvay Process Co	Syracuse, N. Y.
Erie County Savings Bank	Buffalo, N. Y.
E. Cantwell	Newark, N. J.
Drexel Building	Philadelphia, Pa.
Wilson Bros	Philadelphia, Pa.
Bergner & Engel Brewing Co	Philadelphia, Pa.
Bailey, Banks & Biddle	Philadelphia, Pa.
Philadelphia Exhaust Ventilator Co	Philadelphia, Pa.
Manufacturers' Club	Philadelphia, Pa.
"The Stratford"	Philadelphia, Pa.
Wm. B. Glen	Philadelphia, Pa.
John Wanamaker	Philadelphia, Pa.
Thompson's Spa	Phiiadelphia, Pa.
Wm. H. Morris	Philadelphia, Pa.
W. N. Hallman	Philadelphia, Pa.
Owen McCarthy	Pittsburga, Pa.
J. White	Pittsburgh, Pa.
Schwabe's Restaurant	Pittsburgh, Pa.
Fred Kamm	Pittsburgh, Pa.
Chas. Kopff	Pittsburgh, Pa.
Chas. Drum	Pittsburgh, Pa.
Harry Heck	Pittsburgh, Pa.
W. H. Stakely	Pittsburgh, Pa.
Scheving & Clark	Washington, D. C.
Edw. P. Mertz	Washington, D. C.

NAMES OF PARTS.

A	Armature.
B	Commutator.
C	Shaft.
c	Pulley Key.
D	Pulley.
E	Keeper.
F	Bed Plate.
G	Field Coils.
H	Keeper Bolts.
I	Washer.
i	Pillow Block Bolts.
J & K	Pillow Blocks.
j & k	Oil Hole Plugs.
L & M	Pillow Block Bearing.
l & m	Rings.
N	Cap Screws.
O	Dowel Pins.
P	Rails.



Parts of Old Style Stationary Motor.

NAMES OF PARTS.

p	Lag Screws.
Q	Rail Bolts.
R	Rocker Arm.
S	Brush Holders for small sizes of motors.
s	Brushes for small sizes of motors.
T	Brush Holders for large sizes of motors.
t	Brushes for large sizes of motors.
U	Connecting Board.
V	Brush Holder Cables.
W	Carbon Brush Holders.
w	Carbon Brushes.
X	Pet Cocks.
Y	Eye Bolt.

(*Ventilators continued.*)

Mrs. Lewis	Washington, D. C.
C. D. Kenny	Washington, D. C.
B. F. Brenninger	Washington, D. C.
U. S. Cruiser "Yorktown"	Washington, D. C.
Clifton Café (Gillingham)	Washington, D. C.
H. C. Ewald	Washington, D. C.
W. F. Dabney	Washington, D. C.
Ponce de Leon Hotel	St. Augustine, Fla.
Alcazar Hotel	St. Augustine, Fla.
Albert Heim	New Orleans, La.
J. B. Harrison	New Orleans, La.
Joseph Hirn	New Orleans, La.
Fritz Huff	New Orleans, La.
D. Jackson	New Orleans, La.
Chas. Jaeger	New Orleans, La.
N. Kuntz	New Orleans, La.
Leon Lamothe	New Orleans, La.
Moses Lobe & Son	New Orleans, La.
D. Lopez	New Orleans, La.
J. R. Beckwith	New Orleans, La.
John Bitterwolf	New Orleans, La.
P. L. Causachs	New Orleans, La.
W. T. Cluverius	New Orleans, La.
J. B. Cameron	New Orleans, La.
St. Cyr. Fourcade	New Orleans, La.
Lawrence Fabacher	New Orleans, La.
Louis George	New Orleans, La.
Grouchy & Domecq	New Orleans, La.
Lehman, Stern & Co	New Orleans, La.
Louisiana Restaurant	New Orleans, La.
London, Liverpool & Globe Insurance Co	New Orleans, La.
Bernard Meyers	New Orleans, La.
John Miller	New Orleans, La.
Eugene May	New Orleans, La.
Manion & Co	New Orleans, La.
Val. Merz	New Orleans, La.
John McClosky	New Orleans, La.
Samuel S. McCune	New Orleans, La.
John Oberlander	New Orleans, La.
H. C. Quirk	New Orleans, La.
J. Rienhard	New Orleans, La.
Charles Rhodes	New Orleans, La.
Chas. Rieder	New Orleans, La.
Eugene Robinson	New Orleans, La.
John T. Shaw	New Orleans, La.
Paul Schreiber	New Orleans, La.
O. H. Schonhausen	New Orleans, La.
J. Schnitzer	New Orleans, La.
Schmidt & Zeigler	New Orleans, La.
Wm. Troegel	New Orleans, La.
M. Vonderbank	New Orleans, La.
Jos. Voegtle	New Orleans, La.
Dr. Jas. West.	New Orleans, La.
Chas. L. Wirth	New Orleans, La.
H. Wenger	New Orleans, La.
Emile Bauman	New Orleans, La.
Joe. J. Hochstader	Birmingham, Ala.
C. H. Nabb	Birmingham, Ala.

(*Ventilators continued.*)

G. J. Houseman	Birmingham, Ala.
Jean Gullatuire	Birmingham, Ala.
Greenville Electric Light Co	Greenville, Miss.
Kinsleys	Chicago, Ill.
American Exchange Bank	Chicago, Ill.
New Haven Oyster House	Chicago, Ill.
Phœnix Building	Chicago, Ill.
Rookery Building	Chicago, Ill.
Mandel Brothers	Chicago, Ill.
Commercial National Bank	Chicago, Ill.
Home Insurance Building	Chicago, Ill.
B. Hagelon	Elgin, Ill.
Phil. Freiler	Elgin, Ill.
Kaufman, Straus & Co	Louisville, Ky.
John C. Lewis	Louisville, Ky.
Louisville Banking Co	Louisville, Ky.
W. H. Day, Confectioner	Louisville, Ky.
Clayton & Pate, Club Room	Louisville, Ky.
Kline & Son, Confectioners	Louisville, Ky.
Boulier Brothers, Turf Exchange and Restaurant	Louisville, Ky.
Geo. Wolf & Co., Jewelers	Louisville, Ky.
Suburban Club Rooms	Louisville, Ky.
Henry Heath, Billiard Parlors	Louisville, Ky.
J. A. Flexner, Druggist	Louisville, Ky.
Seelbach's Hotel	Louisville, Ky.
Newmarket Pool Room	Louisville, Ky.
High School	Cleveland, O.
Society for Savings Building	Cleveland, O.
High School	Akron, O.
Hughes & Keith	Denver, Colo.
Frederick Sanders	Detroit, Mich.
Andrew Hair	Detroit, Mich.
Daniels & Ives	Detroit, Mich.
F. Long	Topeka, Kans.
J. C. Hopkins	Topeka, Kans.
Dominion Electric Manufacturing Co	Montreal, Can.

MISCELLANEOUS.

Dinsmore Manufacturing Co	Boston, Mass.
American Health & Supply Co	Boston, Mass.
Union Square Theatre	New York City
Florence Ice Machine Co	New York City
Henry Randolph	Newburgh, N. Y.
U. S. Treasury Department, Register's Division	Washington, D. C.
Chas. G. Shultz	New Orleans, La.
Mer. Broom Manufacturing Co	New Orleans, La.
W. R. Irby	New Orleans, La.
Dr. A. H. Duvall	Louisville, Ky.
J. F. Jungblut & Co	Chicago, Ill..
Dudson, Fisher & Brockman	Minneapolis, Minn.
Dr. F. L. Stone	Minneapolis, Minn.
Carpet Cleaning Works	Topeka, Kans.

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I. D. Circular 25
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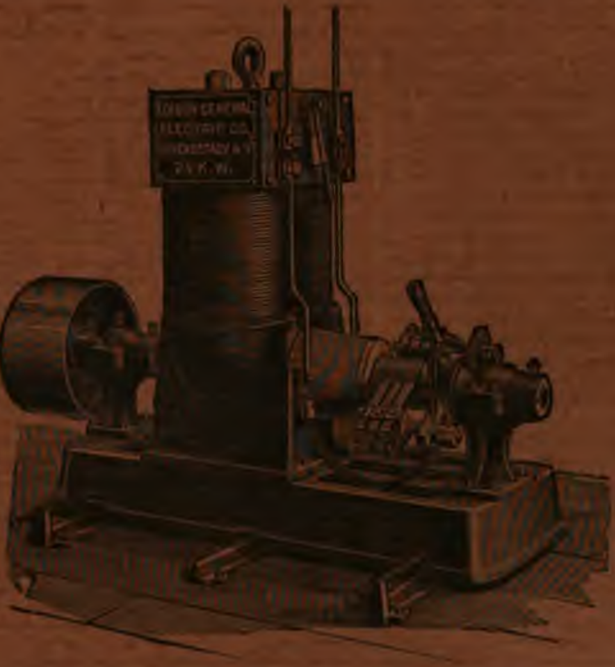
DIRECTIONS

FOR

SETTING UP AND RUNNING

EDISON ELECTRIC MOTORS.


EDISON GENERAL
ELECTRIC CO.
SCHENECTADY N.Y.
7½ K.W.

EDISON GENERAL ELECTRIC CO.,
EDISON BUILDING, BROAD STREET,
NEW YORK CITY.

FACTORIES: NEW YORK CITY, SCHENECTADY, N. Y., and SHERBROOKE, P. Q.

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INTRODUCTION.

In preparing these instructions for setting up and operating electric motors it has been assumed that the electrical and mechanical features of the machine are understood.

The use of technical phrases has been avoided as much as possible, and all instructions are based on actual practical experience, derived from daily work with the motors.

The owner, user or attendant having a motor in charge should appreciate these facts and bear in mind that the following instructions have been made as brief and pointed as possible.

EDISON GENERAL ELECTRIC CO.

NEW YORK, Sept. 1, 1890

EDISON ELECTRIC MOTORS.

Location, Setting and Starting of Motor.

THE motor should be located in a clean, dry place, and preferably in a room of low temperature. See that the motor has a level, solid foundation. For quiet running *a solid foundation is a necessity.* The foundations should be of a sufficiently substantial character to obviate all vibration while the machine is in operation.

Care must be taken to insulate the motor entirely from "earth." The base frame should be thoroughly treated when warm and dry with some moisture repellant, such as asphalt varnish. Set motors on rails, so that as the belt stretches the motor can be moved by the adjusting bolts to lengthen distance between centres, and then take up slack.

Wait until the motor has been started and properly lined up before screwing the rails to the foundation.

ASSEMBLING.

UNDER no circumstances allow the field magnets or armature to be struck by any hard body. Bruising these parts injures the insulation and invites disaster.

Compare the articles with the list sent. All deficiencies or breakage must be reported within 10 days after receipt of goods.

If the motor is sent with all parts assembled, see that the field magnet connections are undisturbed and in good order, also that the brush holder cables are attached as shown on the diagram.

Before starting, clean all parts of the motor thoroughly, make sure that nothing is lodged in air space between armature and pole pieces; remove caps from pillow blocks, wipe out oil cavity carefully and fill with oil; see that rings hang free in the slots cut in the sleeves and replace cap.

If the motor is sent with the armature separate, remove both pillow blocks, and after wiping the bearings and shaft, carefully slip the armature into its place and screw the pillow blocks down in position, observing the same care about cable connections and pillow blocks as directed above. If necessary, rinse the bearings carefully with hot water and then see that they are dry before setting the armature in place.

Be careful that the arrow on the sleeve of the self-oiling bearing points in the direction of rotation, and that the rings are placed in their slots after placing the sleeve in position.

NOTE.—See special instructions in regard to self-oiling bearings on page 15.

If the motor is sent with parts unassembled, proceed as follows:

Clean thoroughly the ends of the magnet cores and contact surfaces of keeper and pole pieces, as there must be a perfectly clean contact of iron surfaces when the magnet cores are joined to the keeper and pole pieces.

Standing at the long end of the bed plate, put the magnet marked " R " on the right and the magnet marked " L " on the left. Place keeper in position and screw in the keeper studs.

Connect terminals of field magnets with posts on head board and back board, after seeing that the brass contact blocks are bright and clean.

Lift the armature into its place between the magnets, with the commutator at the long end of the bed plate. Put on the pillow blocks, seeing that they are firmly secured.

Put the brush holder studs in the rocker arms, seeing that the insulating blocks are so placed as to effectually insulate the studs from the rocker arms.

Make connection between the brush holder studs and the binding posts on each pole piece by means of the brush holder cables, and set up the nuts and lock nuts.

Adjust the brushes in their proper position, seeing that the + and — brushes are diametrically opposite and that the brushes of like sign have contact in the same line along the commutator.

"If there is any evidence of moisture in armature or magnets it must be thoroughly dried out before starting the motor. A bruise upon armature or magnets, or the presence of moisture, is likely to result in a short circuit, and cause the part to be burned out."

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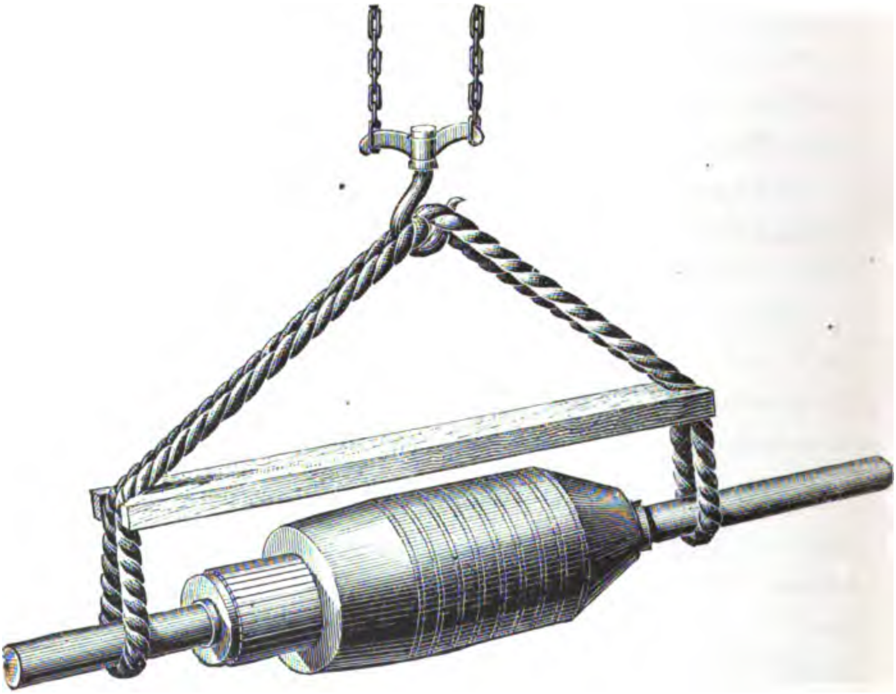
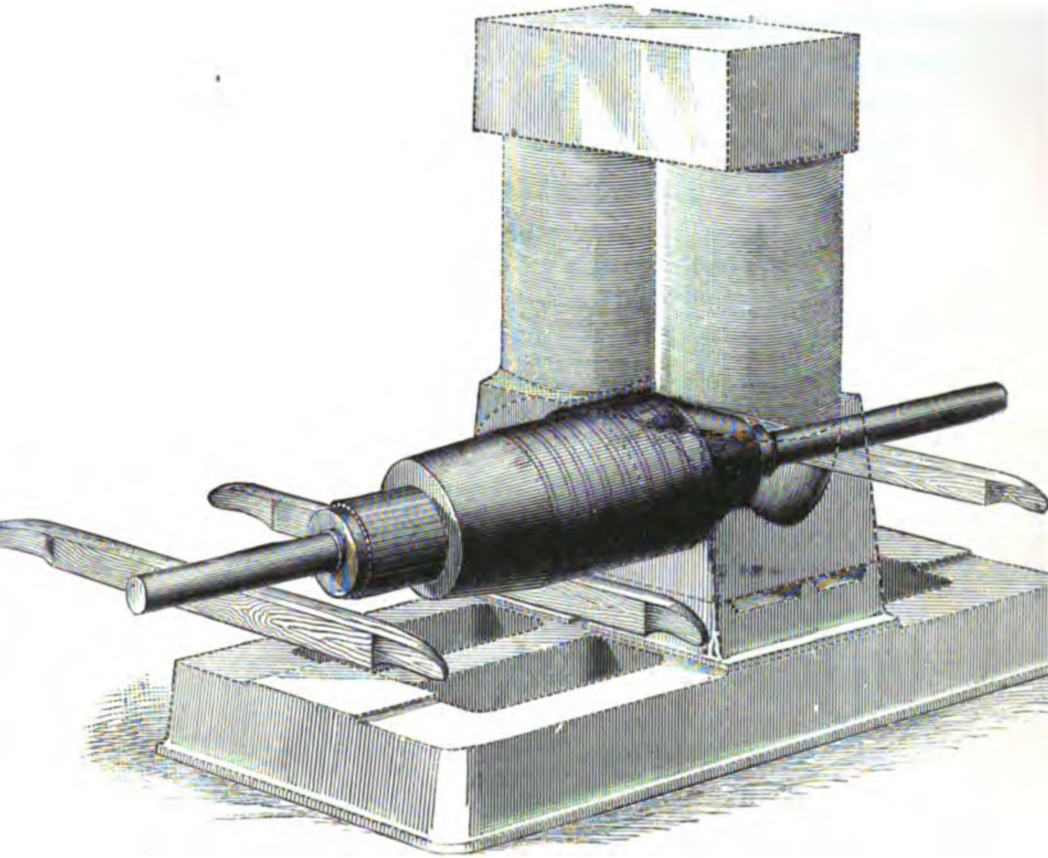
Directions for Handling Armatures.

In setting up motors it is very important that the armature and field cores be carefully handled so as to avoid abrasion of the insulation of exterior and interior parts.



METHOD OF SWINGING ARMATURE FOR LARGER SIZES OF MOTORS.



View showing method of removing Armature from Fields or replacing Armature in larger sizes of Motors.

Exercise great care in handling.

Use only rope sling and wooden bars.

Handle as much as possible by the shaft.

When it is necessary to lift on the body of the armature, be careful, especially with the larger sizes of motors, to take hold only where the bands around the body are, never on the canvas heads. ***Use a pad of felt or cotton waste between the bar and armature body.***

Never, under any circumstances or in any manner, make use of the commutator in handling the armature.

Do not allow the weight of the armature to rest on the commutator for a moment.

Do not touch it with the bars or slings.

Do not lay an armature on the floor unless some sort of cushion is placed underneath. Armatures, as stated before, should be lifted and carried by the shaft as far as possible.

All surfaces should be perfectly cleaned and free from dirt.

The motor should be carefully leveled up, and its pulley and shaft accurately lined with the shaft and pulley of the machine to be driven. Satisfactory operation depends upon careful setting of the motor.

Driving Pulley.

THE pulley sent with motor is of proper diameter and width of face.

It is not desirable to use a larger diameter pulley than that sent.

A smaller pulley is objectionable, because to obtain necessary friction and belt contact, increased tightening of the belt will be necessary. This is liable to result in heating of the bearing.

Where smaller diameter of pulley is unavoidable, we advise that the width of belt and face of pulley be increased from 25 to 50 per cent. This will tend to give additional belt contact, and admit of running a slack belt.

Belts.

BELTS should be perfectly straight and of equal thickness throughout. They should be made endless. Where lacing is unavoidable, the ends to be laced should be cut at right angles to the sides. The lace holes should be formed by an oval punch, the long way of the punch extending lengthwise of the belt, reducing the section the least. Commencing at the middle of the belt, lace evenly so as to give uniform strength, and never cross the lace on the inside of the belt. If copper or other rivets are used, the heads should be let in rather below the level of the inside surface of the belt, to prevent contact with the pulley.

If the lacing on one side breaks, replace it promptly, no matter if the break is slight. If it is neglected even for a short time, the belt is liable to draw out of shape and remain crooked ever afterwards.

Belts and pulleys should be kept clean and free from accumulations of dust and grease, and particularly from contact with lubricating oils, some of which permanently injure leather. Tallow applied blood warm will render leather belts pliable.

Where possible, belts should be boxed in to keep out dirt and grease and prevent accidents.

Both short and vertical belts are objectionable. They always require more tension than long or horizontal ones. As the transmitting power of a belt increases greatly with an increase of arc of contact, the slack side should always be on top.

High speed belts should have neither laced, hooked, nor metal fastened joints of any character; the belt should have only carefully lapped and glued joints; laps may be pegged or riveted. Belts making an inclination of not over 45 degrees with the horizontal should have sufficient width and speed to run moderately slack without slipping; they will then last longer and have less tendency to heat the bearings. Tightening pulleys should only be used on vertical belts, they should be of large diameter and run on the slack of the belt. Pulleys should be but slightly convex. The most effective tightener is the weight of the belt on its slack side, which increases adhesion by increasing circumferential contact with the pulley. The adhesion will be decreased if the pulley face is too convex.

For ordinary light work, single leather belts are most satisfactory. The flesh side of a leather belt is the stronger and less liable to crack, hence should be on the outside. Small pulleys injure belts by too much flexure. A belt will not carry as much when new as it will after a few months careful use. Best leather belting should have a tensile strength of 350 pounds per square inch of section, or about 55 pounds per inch of single belting. The transmitting power of single to double belting is as 7 to 10.

Avoid excessive tension, as this not only permanently injures the belt, but also heats the bearings of motor and driven machine.

The following formula will enable one to calculate either velocity, width or H. P. for any arc of contact of driving pulley when the other two are known:

$$W = \frac{H.\,P. \times 700}{V \times C} \quad \text{When}$$

W=width in inches.
V=velocity of belt in feet per minute.
C=contact co-efficient having the following values:

For	180	degrees	contact	1.00
"	157½	"	"	.92
"	135	"	"	.84
"	112½	"	"	.76
"	90	"	"	.64

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When the pulleys are of the same diameter the following will be sufficiently accurate :

$$\text{Width in inches} = \frac{H.\ P. \times 6{,}000}{\text{velocity} \times \text{contact in feet.}}$$

The length of belt required can be obtained very closely by adding one-half the sum of the circumferences of the two pulleys to twice the distance between their centers.

STARTING.

START the motor for the first time with the belt off. See that the lubricating rings rotate freely with the armature shaft, and that the lower part of the rings dip in the oil.

NOTE.—See remarks on self-oiling bearings on page 15.

Close head board switch, making sure that the regulator handle is in the position "arm off," before closing.

Turn the arm of the regulator slowly from the position marked "arm off" to position marked "arm on." Never allow the regulator arm to remain for any length of time on any of the intermediate blocks.

After moving the rocker arm until the brushes come into position of least sparking, securely fasten it.

STOPPING.

OPEN head board switch *quickly* to point where it is held in position by catch. Move arm of regulator to first position marked "arm off." It is best to keep the brushes raised off the commutator when the motor is not in action. Never raise the brushes with the current on. When motor is not in operation, always leave head board switch open.

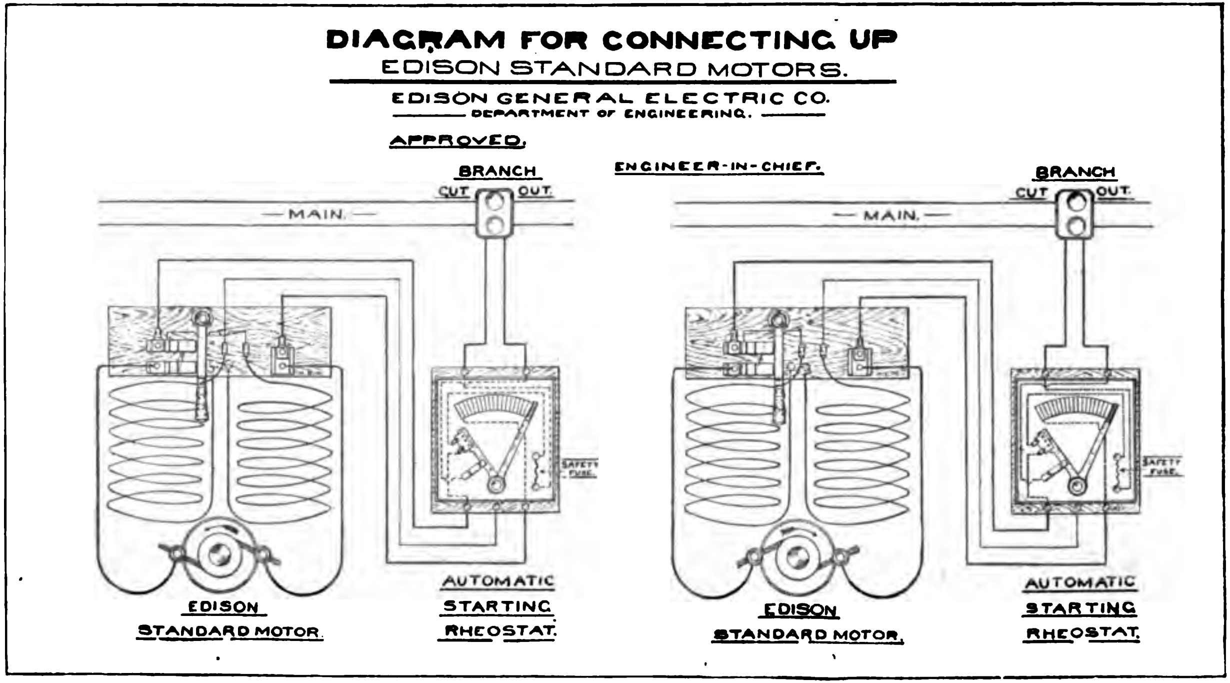


DIAGRAM FOR CONNECTING UP
EDISON STANDARD MOTORS.
EDISON GENERAL ELECTRIC CO.
DEPARTMENT OF ENGINEERING.
APPROVED.
ENGINEER-IN-CHIEF.
BRANCH
CUT OUT.
MAIN.
SAFETY FUSE.
EDISON
STANDARD MOTOR.
AUTOMATIC
STARTING
RHEOSTAT.
BRANCH
CUT OUT.
MAIN.
SAFETY FUSE.
EDISON
STANDARD MOTOR.
AUTOMATIC
STARTING
RHEOSTAT.

PLATE A.

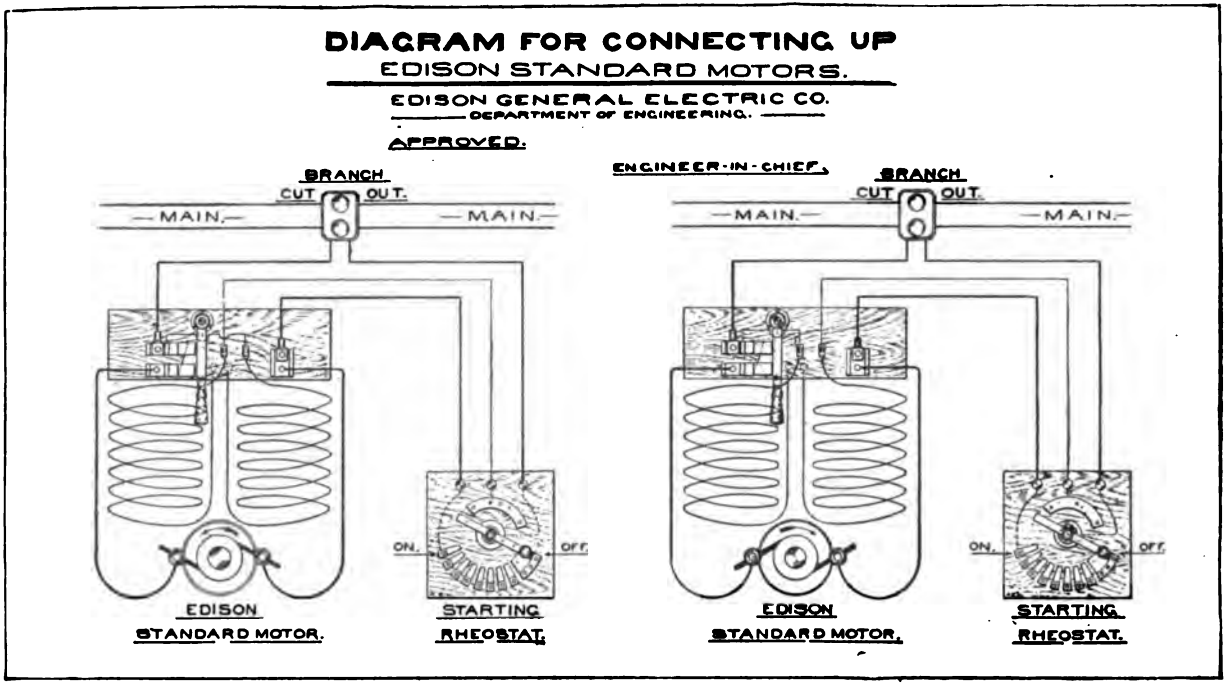


DIAGRAM FOR CONNECTING UP
EDISON STANDARD MOTORS.
EDISON GENERAL ELECTRIC CO.
DEPARTMENT OF ENGINEERING.
APPROVED.
ENGINEER-IN-CHIEF.
BRANCH
CUT
OUT.
—MAIN.—
—MAIN.—
ON.
OFF.
EDISON
STANDARD MOTOR.
STARTING
RHEOSTAT.
BRANCH
CUT
OUT.
—MAIN.—
—MAIN.—
ON.
OFF.
EDISON
STANDARD MOTOR.
STARTING
RHEOSTAT.

PLATE B.

These directions will be more readily comprehended by reference to plates A and B, upon which the parts referred to are given.

Plate A shows the connections for right and left handed rotation of armature when the automatic starting rheostat is used, and plate B shows the same where the ordinary starting rheostat is employed.

Overload.

NEVER allow a motor to run with an overload. Have a margin of 15 to 25 per cent. over the power required. The current taken by a constant potential motor is proportional to the load; and, as the larger the motor the higher the efficiency, there is a clear advantage in having a larger motor than is required.

It is advisable to use an ampere meter in circuit with every motor of 20 horse power or larger.

Cleanliness about the Motor Essential.

ALL parts of the motor should be kept neat and clean. Dirt, copper dust and oil should not under any circumstances be allowed to gather on any part, especially in crevices near those parts which are carrying current.

Copper dust in even small particles may be a source of much annoyance. It is very detrimental to the motor and will seriously imperil the durability of the insulation on magnets and armature.

Oil cans, tools, bolts and pieces of iron should be kept away from the motor, as they are liable to be drawn into the field and injure the armature.

A good rule is, *never allow loose articles of any kind to be* *placed upon any portion of the motor.* They are liable to fall upon the armature or commutator.

Brass or copper oil cans are the best to use, as they are non-magnetizable.

Switches, Connections and Contacts.

A LARGE, clean surface contact is important. The contact surfaces of switches and all connections should be sufficiently firm to secure good conductivity and should be kept clean and bright. All connecting screws sbould be set down firmly and securely.

All contacts and connections should be frequently inspected while motor is in operation to see that there is no undue heating.

Oil.

THE high speed at which the motor runs requires a lubricant especially adapted for such speeds. Uniformity of quality and absolute reliability are of first importance.

The value of an oil depends more upon its power to reduce friction and prevent the excessive development of heat, than upon its market price. Cheapness can never compensate for inferior quality.

The characteristics which should be possessed by the oil in order to be most efficient as a lubricant for motors, are:

1. Sufficient density or body to keep the surfaces, between which it is interposed, from coming in contact under greatest pressure.

2. The greatest adhesion to metallic surfaces, and the least cohesion in its own particles, are qualities of the best oils, and in this respect fine mineral oils stand first.

3. The fluidity of the oil should be as great as is consistent with the above conditions.

Keep the oil free from gritty matter. All foreign matter injures the quality of the oil, and tends to increase the heat of the bearings.

Economy in the use of oil depends largely upon the methods of applying it. By the use of our self-oiling bearings thorough lubrication can be depended upon, with the least possible expenditure of oil.

Oil, after passing through the journal, is drawn off from the interior of the pillow block. If of good quality, it has not deteriorated and may be filtered and used over again.

Do Not Fail to Keep the Bearings in Good Condition.

ATTENTION must occasionally be given to the bearings of the motor while running.

> Watch the bearings on a new motor very closely for a few days and see that the oil is well distributed.
>
> After a new motor has been operated a few days, all bearings should be made to work at a normally low temperature.

Under proper conditions no reasonable excuse can be offered or accepted for abnormal heating. If it exists, it needs immediate investigation and remedy.

> After being in operation a short time, a certain amount of heat is imparted to the bearings by the armature—any undue heating aside from this requires immediate attention.
>
> The temperature may reach blood heat when running with full load. The commutator bearing may be expected to become slightly warmer than the pulley bearing.

Undue heating may result from a variety of causes. Among these may be mentioned insufficient quantity or poor quality of oil, dirt or gritty matter in oil, a badly scraped bearing, rough journal, boxes too tight, belt too tight, an armature shaft slightly bent, or motor overloaded.

The cause of the heating should always be ascertained and remedied, and the boxes removed, cleaned, scraped and accurately refitted before starting up again.

After removing a pillow block be scrupulously careful in replacing to see that contact surfaces and steady pins are free from grit, fibres of waste, or any kind of dirt.

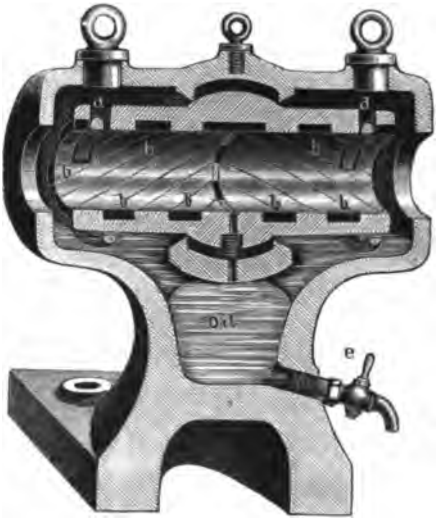
If the ***bearings*** should become ***considerably worn, there is danger that the armature may rub*** on the interior faces of the pole pieces and loosen the binding wires, which is sure to ruin the armature. By observing the position of the armature in the field, it may readily be seen whether the bearings are worn down to any considerable extent.

A small amount of wear downwards may be remedied by raising the pillow blocks with a piece of cardboard or sheet iron. If they are badly worn, or worn sideways, the bearings should be rebabbitted.

Bearings out of line may be due to:

1. An uneven foundation causing a distortion of motor base;
2. Or improper setting and bolting of the pillow blocks;
3. Or improper fitting in place of the babbit shells.

Self-Oiling Bearings.



Our self-oiling bearing for motors, which is shown above, aims to secure absolute reliability against heating, as well as perfect and economical lubrication.

Little attention is required, and there is much less danger of undue heating than with the ordinary bearing.

These bearings can be fitted to existing motors in place of the old bearings, and are great savers of oil.

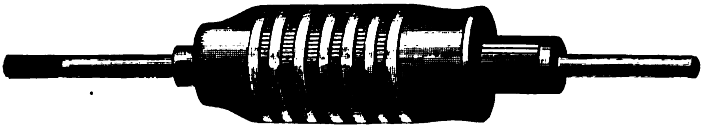
With the construction shown in cut, the revolving rings "*a*" carry from the reservoir to both ends of the sleeve a continuous supply of oil which is swept by the action of the revolving shaft, on the spirals "*b*," towards the centre of the bearing, where it is collected by the central groove, and returned by the vertical hole to the reservoir where it has time to settle and cool.

By these means a continual circulation of oil through the bearing is automatically started, kept up and stopped by the motion of the shaft, the bearings requiring no attention beyond a periodical examination, and, when necessary, renewal of the oil, which may be drawn off from the reservoir by a pet cock tapped at "*e*."

This bearing will only act for running in one direction. To run the shaft the other way the sleeve would have to be turned end for end. It is, therefore, *imperative* that the bearings be correctly put together. For this purpose an arrow is stamped on the upper surface of the ball bearing of the sleeve, and the sleeve must be set so that looking down on the bearing the upper surface of the shaft runs in the direction that the arrow points.

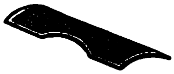
The bearings should be examined once a week, although the oil does not require renewal as often as this.

C



ARMATURE.

POLE PIECES.



SCREEN.

Armature.

THE armature is the portion of the machine that revolves between the pole pieces of the field magnet. Between the pole pieces and above the armature is a wire screen for preventing dirt from falling on the armature while revolving. This screen should be taken out at least once a week and the surface of the armature examined as it is slowly turned over, in order to see that it is not rubbing against the pole pieces.

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If this rubbing occurs, it will soon lead to the bursting of the bands holding the wires of the armature in place, with the consequent spreading out of the armature wires against the pole pieces, which would destroy the armature.

Commutator.

THE commutator is the portion *C* of the armature upon which the brushes rest.

Special care and attention must be given to this part of the machine, and it should be kept perfectly smooth and round.

The perfect or imperfect condition of the commutator on a motor is strong evidence of the care which is taken of it. There is a certain knack in caring for a commutator easily acquired by any painstaking person.

Prevention, not cure, is the correct rule for commutator troubles. The life of a well cared for commutator should not be less than two years of continuous running and may be more. A little roughness is easily removed, but if allowed to increase it will soon be too late for any remedy except the lathe.

When in good condition, the commutator ought not to spark at all under any conditions of load. Its surface should always retain, while running, a dark chocolate color with a polished or glazed appearance. It should feel perfectly smooth and even when tested by resting the flat portion of the finger-nail against the revolving commutator, with the palm of the hand upward. The back of the nail in this way is very sensitive to any irregularities of the surface.

If accidentally scratched the commutator may be polished with No. 00 sand-paper moistened with a drop of sperm oil or vaseline, and cleaned with a piece of canvas or chamois skin. *Emery paper or emery cloth should not be used to scour the commutator*, as the very fine particles of emery, settling in the divisions between the bars, may cause short circuiting at the commutator. Occasionally the commutator should be wiped off with an oiled rag. A file should not be employed.

Waste should not be used to clean the commutator, as the lint is apt to get under the brushes and cause sparking.

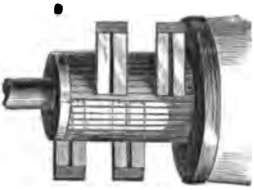
Avoid the use of all special kinds of grease or wax offered for sale for use on commutators; they do much more evil than good.

If the commutator is but slightly rough or uneven or out of true, it may be ground down by the use of sand-paper in a block hollowed out to fit its true circumference. If in very bad condition, however, it should be turned down with a tool and a special rest.

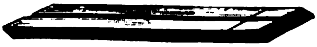
For turning off commutators the armature should be given to a careful and competent machinist. When the armature has to be removed for any cause the greatest pains must be taken in handling. *Armatures are often burned out because of some blow or bruise received from careless handling.*

In turning off a commutator the cut should stop before reaching the end of the bar. This is important to preserve the insulation and to keep the iron collars intact for receiving a new set of bars.

The amount of wear on a commutator which may be allowed before sending to shops for repairs depends on the depth of the commutator bars, and the amount of current they are required to carry. This varies in the different machines.



ARRANGEMENT OF BRUSHES.



BRUSH.

Adjustment of Brushes.

THE cast-iron collar at the end of the commutator should have center punch or chisel marks placed upon it diametrically opposite each other, each of them in line with one of the strips of mica insulation, and in setting the brushes these two opposite marks should be taken as a standard, by placing the points of the brushes exactly on the mica strips in line with the marks.

Fasten the brush holders in such a position that the brushes on one side do not bear on the same part of the commutator, considered lengthwise, as the brushes on the opposite side. This alternate arrangement prevents unequal wear upon the commutator.

The end of the brush should be carefully beveled so as to conform accurately with the surface of the commutator, the outer layers of wires being trimmed off square at the end to about one-third the total depth of the brush. The brush should bear lightly upon the commutator, and every part of the beveled end should rest upon it. The pressure should be just sufficient to insure good contact and avoid all cutting and scratching. Be sure that the brush holder stud is secured to the rocker arm so that the brushes have a spring touch on the commutator. Brushes may spark from imperfect contact, caused by the stud being turned, so that the slot is too far around.

When at rest the brushes should always be raised from the commutator by means of the clips provided for the purpose. If left in contact with the commutator they are liable to be injured or perhaps ruined by an accidental reversing of the direction of rotation.

When the brushes are raised up from the commutator they should stand off from it about a quarter of an inch—not more than this.

OUR MOTORS CAN BE OPERATED UNDER FULL LOAD WITH ABSOLUTELY NO SPARK AT THE BRUSHES.

IT IS VERY NECESSARY THAT PERSONS OWNING MOTORS FULLY APPRECIATE THIS FACT, AND ALWAYS AIM TO SECURE THIS CONDITION OF OPERATION.

A motor in operation with a spark at brushes is *prima facie* evidence of overload or carelessness of attendance. Such a condition of affairs should not be allowed to continue.

Causes of Sparking and Remedies.

1st C. Brushes not set at neutral point.

R. The brushes having been previously set diametrically opposite, they can be readily adjusted to the neutral point by moving the rocker arm backward or forward until the non-sparking point is found.

2d C. Brushes not set at diametrically opposite points.

R. Great care must be taken to have the brushes set diametrically opposite before starting, as their readjustment while running is troublesome. If any individual brush sparks while the other brushes are working perfectly, it is out of alignment.

To adjust, shift brush in holder and ascertain non-sparking point by trial and error method.

3d C. Brushes set so as not to get full bevel to the circumference of commutator.

If brushes are set crooked, and do not bear evenly on the commutator, sparking is apt to result.

R. Readjustment must be made to secure full face of brush at proper level.

4th C. Brushes set with insufficient pressure.

R. This fault can usually be remedied by increasing tension on spring in brush holder.

5th C. Slot in stud rotated too far away from commutator.

R. If all brushes on same side have too little pressure, loosen large nut on end of brush holder stud and turn stud slightly, toward commutator; tighten nut firmly, and give careful attention to adjustment of spring. This can be done when motor is stopped.

6th C. Brushes spread apart and filled with dirt and oil.

Oil and copper dust and dirt will fill in between the wires and spread the brushes.

R. All this can be removed by a thorough washing in benzine, or in hot solution of sal-soda water, or strong potash water. With proper care this will seldom be necessary.

7th C. Brush having loose or crooked wire on edge of brush.

Loose or crooked wires on edges of brushes are usually caused by careless management in putting brush in holder.

R. If this trouble occurs accidentally while in operation, carefully bend the loose wire back and clip it off close to the body of the brush.

Any loose wire causing sparking should be removed.

8th C. Brush with hard burnt ends, which destroy its pliability and increase the resistance at contact with the commutator.

R. Brushes, if so badly burned that pliability is lost, must be thrown away; but, if still pliable and of sufficient length, cut off the burnt portion and file to proper bevel in the brush filing jig.

9th C. Commutator bars, high, low, or loose.

A single high bar in the commutator will vibrate the brush, causing poor contact, and consequent sparking.

R. A heavier tension must be applied to the springs of the brushes until the run is over. As soon as possible the motor should be stopped and the high bar carefully repaired.

If bar is high, set it down in place with a wooden mallet (if possible) and screw up the ring. If this is not possible, file and turn down the high bar and screw up the ring.

If the bar is low, screw the ring up firmly in place and turn the commutator down to a true circumference, or grind it down with sand paper in a hollow block, shaped to the surface of the commutator.

If commutator bars are loose, screw up the ring at end of commutator.

10th C. Loose connection between armature coil and commutator bar.

A loose or broken connection between commutator and armature coil will cause a peculiar blue snapping spark,

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just as the bar leading to it is passing under the brush. This will show itself on the particular bar having the loose connection.

R. This sparking cannot be wholly remedied while running. The spark may be diminished by setting one brush on each side a little in advance of the other. The motor should be stopped as soon as possible and the connections of the armature carefully examined and any loose joints properly repaired.

Take off covering over connections, loosen screws holding connections together.

See to it that the soldering on joint is thoroughly sweated in, and the little pocket holding ends of wire is filled with clean solder, making a perfect joint.

Clean all surfaces, tighten up screws firmly, and renew canvas covering over end of armature.

Be sure that this covering is always strong and whole; do not permit it to get ragged and let in copper dust.

11th C. Section short circuited, either in commutator or armature coils.

R. This fault cannot be repaired unless there is an expert man on hand who knows how to wind an armature. The armature will probably require to be sent to Machine Works or repair shops for repairs.

12th C. Armature damp, with consequent short circuiting of coils.

R. A damp armature can generally be dried out by setting it near a stove or steam radiator, where it will be exposed to moderate heat.

13th C. Commutator dirty, oily, rough, worn in ridges, or out of true circumference.

R. Oil and dirt can be wiped off with a piece of canvas; then polish commutator with fine sand paper. Ridges should be scoured down with sand paper. A commutator out of true should be turned down in the lathe, or with a tool and slide rest, using a slow speed and a fine cut.

14th C. Motor overloaded.

R. This cause of sparking is easily detected at the ampere meter. The proper measures should be taken at once to relieve the motor.

If there is no ampere meter, it is well to notice the temperature of the armature if the motor is doing heavy duty.

The test of temperature can be made after stopping, by laying a glass thermometer on the armature, and covering it with a piece of clean waste to avoid effects of outside temperature. Leave it in contact sufficiently long, and note temperature quickly on removal.

212° F. is a safe temperature.

15th C. Armature coils or commutator sections short circuited by accumulation of copper dust.

The accumulation of copper dust on a motor and its gradual penetration into the coils of armature and fields is often the real cause of serious accident and expensive repairs.

This is one of the principal features which denotes carelessness and inefficient management, and a lack of appreciation of the importance of cleanliness about motors and all electrical apparatus.

R. The remedy is easy to apply. The motors *must* be kept clean of oil and copper dust.

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Remedies 9, 10 and 11 must not be resorted to, unless there is an expert man on hand who understands armature work.

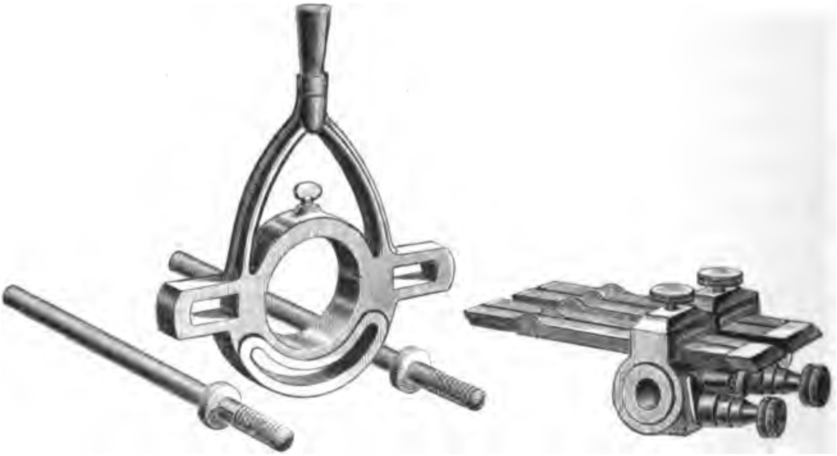
Brushes.

THE brushes are made of hard straight copper wires. The wires should not be allowed to bend, burr up at the ends, or become fused together, and should be kept clean by washing in gasolene, benzine, sal-soda water, or strong potash water.

The brushes should bear upon the commutator with a light tension and flexible contact at the angle of bevel; and the surface of contact between the brushes and commutator should be as great as possible for that angle. The ends should be beveled at an angle of about 60°, the same as the bevel at the rear end of the brush.

The tension of the brushes should not be great enough to cause the wires to spread at the ends.

Brush Holders and Rocker Arm.



THE brush holder is fastened to a sleeve which moves around a short collar, the collar being fastened to a supporting stud.

In adjusting brush holder on the stud, the end of the set screw should first be fitted into the slot on the stud, and the set screw should then be screwed firmly into place to prevent any movement of the collar about the stud.

The stud can then be fixed in position by the stud nuts, and the tension of the brushes on the commutator regulated by means of the tension screws.

It is of the utmost importance that the sleeve should have a free motion about the short collar. In case it works stiffly, take the brush holder apart and ease up the contact with a little fine emery cloth. Never use any oil on this contact, as it makes an increased resistance to overcome, causing heating; oil is also liable to gum, making the parts move less easily.

The position of the brushes on the commutator is adjusted by moving the handle of the rocker arm backward or forward until there is no sparking. The rocker arm is held in place by set screw, shown in sketch.

CARBON BRUSHES.

CARBON brushes may be used for any voltage from 200 to 500 when the current does not exceed 100 amperes.

Voltage.

THE voltage, potential, or pressure, as it is variously called, should never vary more than 5% from the number specified for each motor on the motor plate. Where the motor is of large size and is working up to its full capacity, the variation should not exceed 3%.

Call upon your local Electric Company to measure the voltage when your motor varies greatly from its rated speed.

If volts are in excess of the specified number, the fields will heat and the speed will be increased.

If the volts are scant of the specified number, an excess of current will be used, the armature will become hot and the speed will be diminished.

Sizes of Wire for Connections.

WHERE the motor is further than one hundred feet from the mains (which are supposed to have a pressure in excess of specified voltage) the size of wire may be calculated by the following formula:

$$M = \frac{D \times HP \times 17{,}500}{V \times E}$$

Where $M.$ = Area of cross-section of wire in circular mils.
$HP.$ = Rated horse power of motor.
D = Distance in feet from motor to mains.
E = Rated voltage of motors.
V Permissible drop in volts, from mains.

Or, $M = \frac{21.5 \times C \times D}{V}$ - Where C = current in amperes taken by motor at full load.

House Wiring.

THE wiring should be, if possible, so located that the inspection of it is easy.

The wires should at all places have a covering of moisture-proof, non-inflammable material. When the wiring is liable to abrasion, or is led across metallic surfaces, it should have an extra casing of wood, and when it is led through walls, see that water can not run in and form a short circuit. Fasten the wires securely with porcelain insulators in such a manner as will prevent them from coming in contact with each other or with metallic surfaces, such as steam, gas or water pipes.

Connect the motor as shown by the diagram that will be sent with each motor. Before connecting in the regulator, see that the arm is in the position marked "arm off" on the diagram, and that the head board switch is open.

Place cut-outs near where wires enter the building, also near motor. The diagram furnished with the motor gives the size and position of these.

The wires should be firmly screwed in the binding screws, so as to secure a large and durable contact.

The sizes of house-wires quoted on motor card presuppose proper size of mains, and that the mains are in no case further than one hundred feet from the motor.

If the mains are further than one hundred feet away, the house-wires must be calculated by formula given in paragraph on voltage.

Table of Dimensions of Standard Motors.

H P	Floor Space	Heig't	WT. in lbs.		PULLEY			Rated Speed	
			Net	Shipping	Diam.	Face	Bore	Revs. per min.	Belt speed per min.
¼	16 13/16" x 16"	15"	90	130	3½"	2"	½"	2100	1924
½	21 5/16" x 16 7/16"	16¼"	120	170	3½"	2½"	⅝"	2100	1924
1	24¼" x 24¼"	24"	270	330	4"	3"	⅝"	1800	1884
2½	33" x 28 11/16"	31⅝"	550	655	7½"	3"	⅞"	1475	2895
5	38 11/16" x 32⅝"	35⅛"	830	1035	8"	4"	1⅛"	1385	2903
7½	44⅝" x 33½"	38⅝"	1090	1320	8½"	5"	1¼"	1315	2924
10	48⅜" x 33¾"	42⅜"	1470	1765	9"	6"	1½"	1225	2885
15	57" x 48"	46⅞"	2130	2565	11¼"	8"	1⅞"	1150	3385
20	65 13/16" x 50¾"	50¾"	2880	3075	12"	9"	2⅛"	1085	3407
25	68 5/16" x 52¼"	54"	3570	3970	13"	10"	2⅜"	990	3367
30	73½" x 53½"	56⅞"	4340	4810	14"	11"	2¾"	925	3388
40	83 9/16" x 58"	66⅝"	6800	7770	17"	12"	3"	765	3402
50	92½" x 62⅝"	75"	9790	10590	24"	13"	3¼"	530	3328
80	105 5/16" x 68⅜"	82⅜"	16200	17500	26"	16"	3¾"	430	2927
150	118⅝" x 89½"	93"	31790	34700	44"	21"	5½"	360	4147

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FACTS TO BE REMEMBERED.

Be sure the motor is well insulated from the earth.

Be sure the motor is set upon a substantial foundation.

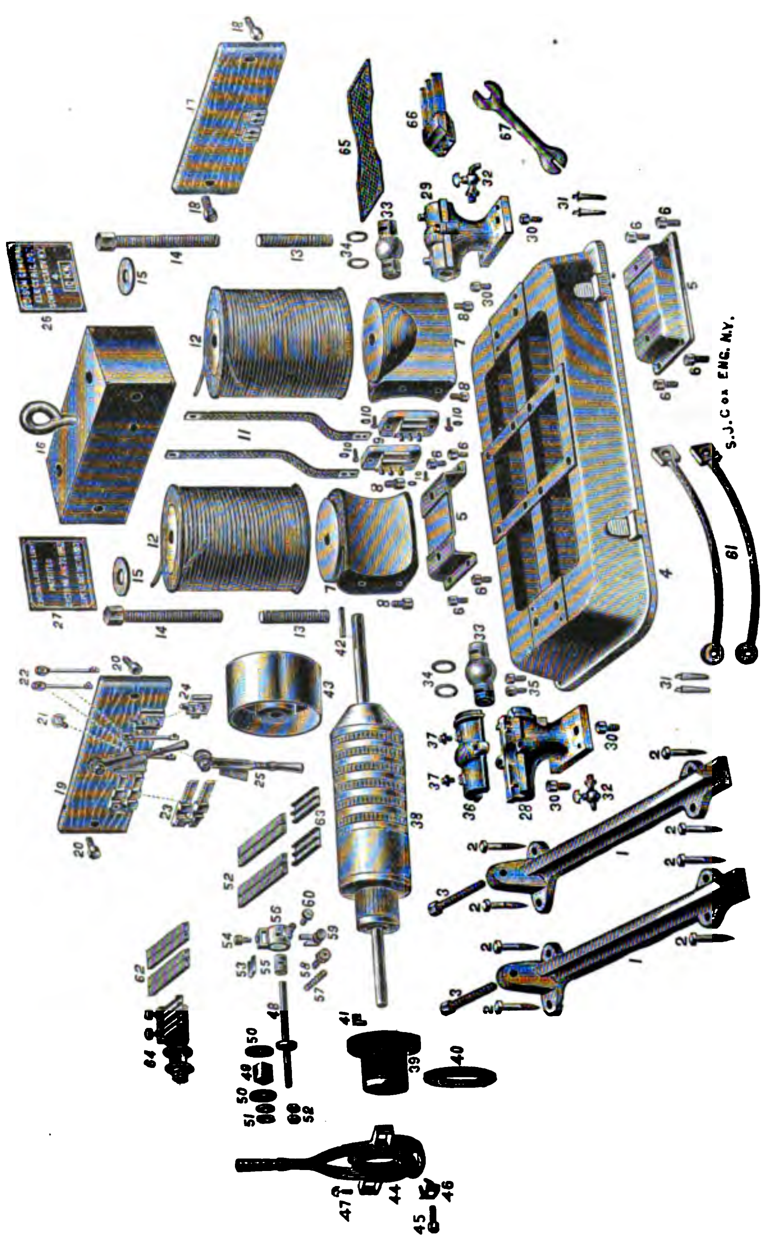
Be sure the head board switch is open, when motor is not in use.

Keep every part of the motor and space around it scrupulously clean.

Keep the brushes properly set and avoid sparking and scratching the commutator.

Do not overload the motor.

Be sure that the wires carrying current to the motor are of ample size to give full pressure of current.


S.J.Cox ENG. N.Y.

List of Parts of Edison Motor.

No. 1. Rails.
“ 2. Lagg screws for rails.
“ 3. Adjusting screws for rails.
“ 4. Bed plate.
“ 5. Zinc bases for fields.
“ 6. Bolts for securing same to bed plate.
“ 7. Pole pieces.
“ 8. Bolts for securing same to zinc bases.
“ 9. Lower terminals for motor leads secured to front side of pole pieces.
“ 10. Bolts for securing same to pole pieces.
“ 11. Motor leads from lower terminals to head board.
“ 12. Field coils and cores.
“ 13. Lower screws for attaching field cores to pole pieces.
“ 14. Bolts for attaching keeper to pole pieces.
“ 15. Washers for same.
“ 16. Keeper.
“ 17. Back board and field coil terminal blocks.
“ 18. Bolts for attaching same to keeper.
“ 19. Motor head board.
“ 20. Bolts for attaching same to front side of keeper.
“ 21. Stop stud for the motor head board switch.
“ 22. Motor head board field terminals.
“ 23. Left-hand motor lead terminal and switch tongue complete.
“ 24. Right-hand motor lead terminal for head board.
“ 25. Motor head board switch bar, including tongue, stud and nut complete.
“ 26. Data plate.
“ 27. Name plate.
“ 28. Lower half of self-oiling bearing, commutator end.
“ 29. Lower and upper half of self-oiling bearing, pulley end.
“ 30. Bolts for securing self-oiling bearing to base plate, either pulley or commutator end.
“ 31. Dowell pins for same.
“ 32. Drip-cock for self-oiling bearings, either pulley or commutator end.
“ 33. Shell for self-oiling bearings, either pulley or commutator end.
“ 34. Rings for self-oiling bearings, either pulley or commutator end.

" 35. Bolts for securing upper half to lower half of self-oiling bearings, either pulley or commutator end.
" 36. Upper half of self-oiling bearings, commutator end.
" 37. Brass plugs for closing oil-holes of upper half of self-oiling bearings, either pulley or commutator end.
" 38. Armature complete.
" 39. Commutator complete.
" 40. Fibre ring for commutator.
" 41. Terminal for end of armature coils.
" 42. Armature pulley key.
" 43. Armature pulley.
" 44. Brush yoke.
" 45. Bolt for securing same.
" 46. Spring washer for use with No. 45, for adjusting tension on yoke.
" 47. Thumb-screw for yoke to secure same to prevent lateral motion.
" 48. Brush holder stud.
" 49. Insulating block for brush holder.
" 50. Insulating rings for brush holder.
" 51. Brass washers for brush holder terminals.
" 52. Brass nuts for brush holder studs.
" 53. Brass pressure trough for brush holder.
" 54. Bolt for securing brushes in brush holder.
" 55. Internal rigid cylinder for brush holder.
" 56. External movable cylinder for brush holder.
" 57. Spring for adjusting tension between internal and external cylinder of brush holder.
" 58. Screw for adjusting tension of spring.
" 59. Screw cam for holding brush out of contact with commutator.
" 60. Bolt for securing internal cylinder rigidly upon brush holder stud.
" 61. Brush holder cables.
" 62. Motor brushes, either side.
" 63. Brush holder troughs.
" 64. Brush holder complete.
" 65. Wire screen for use between field coils for protecting armature.
" 66. Brush filing jig.
" 67. Motor wrench.

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I. D. 160
6-91 100

THE

Electrical Transmission

—AND—

Conversion of Energy

—FOR—

Mining Operations.

◆◆◆

(*Reprinted from* ELECTRIC POWER.)

◆◆◆

EDISON GENERAL ELECTRIC CO.
EDISON, BUILDING, BROAD ST.,
NEW YORK.

Form I. D. 91.
4,'91-500.

EDISON GENERAL ELECTRIC CO.

INSTRUCTIONS FOR THE OPERATION

OF THE

Electric Percussion Drill.

* * *

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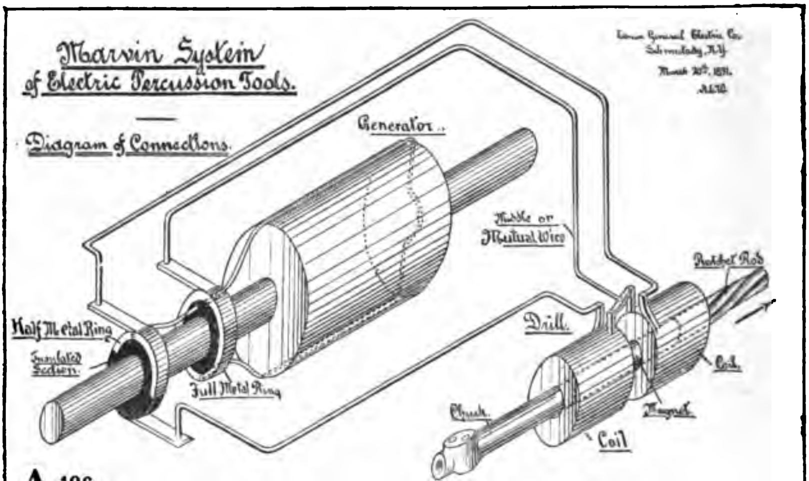

A. 196.

DIRECTIONS FOR SETTING UP AND OPERATING

— THE —

Edison General Electric Co.'s Electric Percussion Drill.

(MARVIN SYSTEM OF PERCUSSION TOOLS.)

THE ELECTRIC PERCUSSION DRILL consists, in general, of two solenoids placed end to end, and having an iron core free to travel endwise, this core being reciprocated by the alternate action of the two coils. To the core is attached the tool holder, or chuck. The two solenoids are connected to generator by three wires comprising two distinct circuits. The generator, by means of a special commutating device, sends current impulses over the two circuits alternately, each solenoid being included in one circuit only. Two impulses, or waves, are developed by the generator at each revolution, one impulse energizing one solenoid and throwing the core in one direction, and the next impulse energizing the other coil, producing reverse movement of the core. The core, or tool, thus moves in synchronism with the generator, and no commutating device or shifting contact is employed on the drill itself.

THE GENERATOR.

The generator is usually made to be separately excited. The commutator consists of one complete metal ring, and one ring of which only one-half the circumference is metal, each ring being insulated from the other and from the shaft; one armature terminal is connected to the metal of each ring. One brush makes contact with the complete metal ring, to which the middle or common wire of the two circuits is connected. Two other brushes, 180° apart, make contact with the other ring, each making contact with the metal segment as the armature revolves. One wire leads from each brush, each forming the outside of the circuit of which the middle wire is return.

The generator should run at a speed of from 575 to 600 revolutions per minute.

The brushes should be carried a little back of the usual non-sparking position to avoid flashing, and they require some adjustment for great changes of load.

The main switch should not be thrown in when the load is on and the machine excited, as it is liable to cause an injurious flash at the commutator. It is better to bring up the fields after the switch is closed.

THE WIRING.

Three wires are necessary between dynamo and drills. The wires are preferably of equal size. It is desirable to run the common or middle wire always between the other two, to avoid mistakes in connecting up. There should be no connection between the two outer wires. Where it is desired to connect a drill to the mains, it should be done by means of the regular drill cable, and a cable switch and fuse box. The line wires should enter the box on the end away from the handle, and the drill cable should be connected to the end nearest the handle. The middle wire enters the middle hole in the box, and at the other end is connected to the middle terminal of the cable connection. The middle wire of the cable can be identified by its being stranded from larger wire than the other two. When the drill is not in use, the current should be shut off at the switch box.

Fifty ampere safety fuses are in the switch box. The box should be so set up that water can not accumulate in it.

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solenoids, each about eight and a half inches long having an outside diameter of about six and three-quarters inches so as to make a loose fit with the casing and an inside diameter of about two and one-eighth inches. These two solenoids are placed so as to be against each other and to end in the casing. The bit plunger plays freely through the centre of these solenoids and is supported by two bearings placed just beyond the outside ends of the two solenoids respectively. The back portion of the casing contains a spiral spring of the form frequently used for car springs. The plunger is composed of a central portion made of wrought iron about fourteen inches long and both the forward and back portion of the plunger which are made of aluminium bronze, are rigidly fastened to this iron portion. The forward portion is about thirteen inches long and carries the bit socket. The back portion is spirally milled for a length of about nine inches, so that the cross-section of this portion is hexagonal. At the extreme back end is a steel buffer which strikes against the cushioning spring.

The spirally milled portion of the plunger is similar to that used in other percussion drills, and causes the drill to revolve upon its axis one-sixth of a complete turn with each stroke. The ends of the coils of wire are brought to contact pieces at the top of the adjacent ends of the two solenoids where there is a socket for receiving the terminals of the cable and thus making electrical connection with the drill. There are three conductors leading from the generator to the drill, one of which is connected to one terminal of each of the solenoids and the other two conductors are connected to the two remaining terminals of the solenoids respectively.

The generator is of the simplest kind, the coils on the armature having their terminals connected to two insulated collars on the shaft.

One collar is a continuous metallic ring and upon this one rests a brush which is connected with the conductor which is common to both solenoids. The other collar is metallic for half of the circle and the remaining half is insulated from the armature wires. Upon this half ring rest two brushes diametrically opposite each other and each brush is connected to one of the two remaining conductors leading to the solenoids in the drill.

If we now revolve the armature of our generator in a separately excited magnetic field, an electric current will flow. Let us say, from the armature to the half ring, then through one of the two brushes which happens at the instant to be in contact with the half ring along the corresponding conductor to one terminal of one solenoid, let us suppose the rear one. Then through the rear solenoid itself and back along the mutual wire to the continuous ring and then to the armature again.

This current in passing through the rear solenoid makes a powerful magnet of it and this tends to pull the plunger back into a position such that the centre of its iron portion shall be in the centre of the rear solenoid.

When the armature moves forward a half revolution the polarity of its wires is reversed and the other brush with its conductor is now in contact with the half circle. Consequently, the current in the mutual wire will be in the reverse direction from that of the former wave, the rear solenoid and its conductor, formerly active, are now out of circuit and the circuit is made through the other conductor and its corresponding solenoid—that is, the forward solenoid.

The magnetic action of this solenoid now tends to make the plunger move forward so that the centre of the iron portion shall be in the centre of the forward solenoid.

Thus we get a reciprocating action of the plunger and every revolution of the armature of the generator will cause a complete stroke of the drill. By varying the speed of revolution of the generator we can make the drill strike any number of blows per minute we choose. In usual practice 600 blows per minute is found to give excellent results. The spiral spring, it will be observed, stores up the energy of the back stroke and returns it to the forward stroke, assisting the magnetic impulse and greatly increasing the strength of the blow.

In order that we may form an unbiased judgment of this drill I will quote the opinion of Andre, perhaps the best authority on power drills, and who many years ago stated the requirements of a first-class power drill, to be as follows :

1. Simple in construction, strong in every part.
2. Few parts, especially moving parts.
3. As light in weight as can be made strong.
4. Take up little space.
5. Striking part of relatively great weight and strike directly.
6. Piston alone exposed to shocks.
7. Piston capable of variable length of stroke.

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8. Sudden removal of resistance should not injure any part.

9. The rotary motion should be automatic.

10. The feed of machine, if automatic, should be regulated by the advance of the piston as the cutting advances.

11. Should be capable of working with moderate pressure.

12. Should be readily taken to pieces.

It may be sufficient to say that the Marvin drill possesses every one of the good qualities Andre specifies and in a most marked degree, but, in describing the good qualities of this drill, we can, if necessary, add considerably more than Andre specifies, for example :

1. It is simple in construction and strong in every part.

2. It has a minimum of moving parts, that is, one.

3. It is very light in weight for its strength, this being possible because of the perfect cushioning at both ends of the stroke.

4. It takes up very little space.

5. The striking part is of relatively great weight and it strikes directly.

6. The length of the stroke is variable at will.

7. The drill cannot damage itself by its own blow.

8. The rotary motion is automatic.

9. It has very few parts.

10. It can be entirely taken apart and put together again inside of ten minutes.

11. There are no joints to be fitted or packed.

12. It is not affected by heat or cold.

13. It can be operated at great distances from the source of power.

14. It has a much higher efficiency than other drills.

15. It is independent of the action of any valve.

16. The rate of striking is independent of the kind of material it strikes.

17. It will operate in the open air without striking anything, and hence can be made to strike an extremely light blow at its full rate, which is very important in starting holes, and so forth.

18. It can be rapidly moved from one position to another at a great distance, since the energy is transmitted through flexible cables,

19. No loss is suffered due to elbows, bends, valves, and so forth, in the conductors.

20. The conductors can be carried on very light sup-

ports, both because of their light weight and because the transmission of energy through them does not tend to distort their position.

The importance of the above characteristics will be apparent to any one who is familiar with the operation of the steam and air drills.

It is interesting to note that in driving the Hoosac Tunnel the average life of the power drills, before sending them to the shop was 50 hours. Even to-day, after a development of twenty-five years, we find that it is common practice to have in the shop one-half the total number of drills employed.

In pushing engineering work it is frequently of paramount importance that the work be done quickly. Therefore, any means of greatly increasing the rate of drilling is extremely valuable. To increase the rate of drilling we must either increase the strength of each blow, or else we must increase the number of blows per minute. A limit to the rate of striking is soon reached, when a valve of considerable weight must be moved from rest the concussion of the by previous blow and when a material substance, such as air or steam, must then fill the space back of the piston and raise the pressure to the working pressure. Also the strains and shocks caused by the valve and the air or steam soon become troublesome as we increase the rate of striking. With the electric drill the speed of rotation of a perfectly balanced cylindrical armature of small diameter has no such limitations and there is apparently no limit to the rate of striking, except the magnetizing and demagnetizing of iron which is already done in daily commercial practice at the rate of 10,000 times per minute with the highest efficiency.

With 800 blows per minute we have already drilled at the rate of four inches per minute a hole 1½ inches in diameter in the hardest Quincy granite and that with an expenditure of energy not exceeding 3 horse power.

I firmly believe that in a comparatively short time we will be furnishing percussion drills whose rate of striking will be several times as much as that we now employ and that with no more and no heavier drills than are now used the rate of driving a heading will be increased many times. The importance of rapid driving of work is practically illustrated by the fact that in driving the Sutro Tunnel, Mr. Sutro offered the men at work, in addition to their regular wages, the following bonus :

RESUME OF FORMULAS FO

By H. W

				SIZE.	WEIGHT.
Conductors as determined by losses therein.	Incandescent Lamps.	Two Wire System.	General Cases.	$M=\frac{\text{T. c. p.}\times D\times 16{,}000}{e\times V\times \text{C. h. p.}}$	$T=\frac{D^2\times \text{T. c}}{V\times e\times \text{C. h. p}}$
				$M=\frac{\text{T c. p.}\times D\times W\times 21.5}{e\times V}$	$T=\frac{D^2\times W\times \text{T.}}{V\times e\times 746}$
			For 100 volt lamps 4.66 watts per c. p.	$M=\frac{\text{T. c. p.}\times D}{V}$	$T=\frac{D^2\times \text{T. c}}{V\times 16{,}000}$
			For 110 volt 3.1 watt lamps.	$M=\frac{\text{T. c. p}\times D\times 2}{3\times V}$	$T=\frac{D^2\times \text{T. c.}}{V\times 24{,}000}$
		Three Wire System.	General Cases.	¼ of corresponding 2 wire case.	⅓ of correspon 2 wire case.
			For 100 volt 4.66 watt lamps.		
			For 110 volt 3.1 watt lamps.		
	For any case.			$M=\frac{C\times D\times 21.5}{V}$	$T=\frac{C\times D^2}{V\times 7460}$
	For power at motor pulley.			$M=\frac{D\times \text{h. p.}\times 16.000}{V\times e\times P}$	$T=\frac{D^2\times \text{h p}}{V\times e\times 10}$
	For minimum total initial cost of plant.				
Generators for minimum total initial cost of plant.					

S IN MULTIPLE ARC.

ARD.

Cost.
$\$=\frac{D^2\times \text{T. c. p.}\times L}{V\times e\times \text{C. h. p.}\times 1{,}000.}$
$\$=\frac{D^2\times W\times \text{T. c. p.}\times L}{V\times e\times 746{,}000.}$
$\$=\frac{D^2\times \text{T. c. p.}\times L}{V\times 16{,}000{,}000.}$
$\$=\frac{D^2\times \text{T. c. p.}\times L}{V\times 24{,}000{,}000.}$
½ of corresponding 2 wire case.
$\$=\frac{C\times D^2\times L}{V\times 746{,}000}$
$\$=\frac{D^2\times \text{h p.}\times L}{V\times e\times 1{,}000\times P}$
$\frac{E\times V}{-V)^2}=\frac{G\times p\times 100}{(100-p)^2}=$ Dollars per h. p. del. by conductor
$\frac{o\ G}{-p}=$ Dollars per h. p. delivered by conductor.

Conductors as determined by safe heating.			
	Bare Copper Wire.	15° C.	$M=C^{\frac{4}{3}}\times 200.$
		35° C.	$M=C^{\frac{4}{3}}\times 170.$
		45° C.	$M=C^{\frac{4}{3}}\times 100.$
	Average Insulated Copper Wire.	15° C	$M=C^{\frac{4}{3}}\times 150.$
		35° C.	$M=C^{\frac{4}{3}}\times 100.$
	Bare Iron Wire.	45° C.	$M=C^{\frac{4}{3}}\times 328.$
	Bare German Silver Wire.	45° C.	$M=C^{\frac{4}{3}}\times 608$

E=E. M F of generator in volts.
e = " " device "
C=current in amperes.
c. p.=candle power of lamps at normal E M. F.
T. c. p.=total candle power of lamps
C. h. p.=candle power per electrical horse-power at normal E. M. F.
M=area of cross-section of wire in circular mils
D=mean distance current is transmitted one way.
V=loss of E. M. F. in conductor (in volts).
$ =cost in dollars.
L =cost of copper per pound in cents.
W=watts per candle-power.
T =weight of wire in pounds.
P =efficiency of device.
p =percentage loss in conductors.
G =cost of generator per h. p. delivered to conductor.

For every foot per month over 300 and under 400	$ 5 00
For every foot per month over 400 and under 500	10 00
For every foot per month over 500	20 00

A bulletin from the Census Department, under date of March of this year, shows that in granite quarrying the cost of labor is 84 per cent. of the total cost of production, and in Massachusetts where the output is much greater than in any other state, and where the longest experience and most approved methods are met with, the labor is 82½ per cent. of the total cost. It will be evident that any labor-saving device in such a field will be extremely valuable.

Another drill of great value to the mining engineer is the diamond drill. The Edison General Electric Company have, during the past thirty days, put upon the market an electric diamond drill which they have been developing for the past two years. The drill is the invention of I. E. Storey, of Denver, Col. It presents a great many advantages over the diamond drills heretofore used, as will be evident from the following description of it:

The drill weighs complete 239 pounds. The average power consumed is about 1¾ horse power and with this expenditure of power the drill will bore a hole of 1¼ inches diameter in hard rock at the rate of two inches per minute, taking out a core of three-quarters of an inch. The drill rod is rotated at the rate of 400 revolutions per minute without any load and when drilling at full load the speed is practically the same.

The drill rod is geared by a single set of gears to an electric motor which revolves at 1,600 revolutions under conditions of full load. The motor has four poles and the keeper joining the poles is in the shape of a surrounding cylindrical shell, which thoroughly protects all the parts of the motor and other parts of the machine.

Upon the drill rod is placed a rotary pump which supplies the drill with the necessary water.

In using the diamond drill the following points are of great importance:

1. The speed should be uniform and automatically controlled very closely, so that removing the load quickly will not permit the drill to run away.

2. The drill should be extremely steady, as any material vibration transmitted by the drill rod to the diamond points is disastrous to them.

3. The drill should run at as high a rate of speed as

is consistent with smooth drilling and a proper supply of water.

4. The drill should be as light and compact as is consistent with the requisite strength.

5. The drill should be capable of being readily and rapidly moved considerable distances and put into operation again with the least loss of time.

Up to the present time, diamond drills are operated by reciprocating engines, and the engine is fastened upon same frame as the drill rod to which it is geared by suitable gearing. The engine usually has two cylinders of the oscillating type to reduce the vibration as much as possible, and eliminate the dead points. With these small engines it is practically impossible to automatically get the close regulation of speed which is desirable, and hence the speed is governed entirely by hand throttling, and the engines cannot be run at very high speed because of the vibration they would produce and because of the rapid depreciation of such engines at high speed. It, therefore, becomes necessary to gear to the drill rod by gearing which is oftentimes objectionably larger, and would become even more so if a higher speed upon the drill rod were attempted, than is desirable. The space occupied by the drilling machine is quite large, as the engine, gears and so forth, occupy much space. This is a great objection in cases of operation in tunnels, shafts, and so forth.

With the electric drill the motion is free from any jar; there are no reciprocating parts, and the speed can be made absolutely constant under any condition of load up to the full load. The speed of the drill rod can be made anything desired up to the full load. The speed of the drill rod can be made anything desired up to several thousand revolutions per minute, and under any conditions of speed above 1,600 per minute there would be no gears whatever. The weight of the electric diamond drill is, for the same power, much less than that of the steam diamond drill and the space occupied is in a direct line with the hole and is extremely small in amount.

The drill can be operated from any existing electric light circuit, and the current for it can be supplied at two miles distance from the source of power by wires of size No. 10 B. W. G., having a diameter of about ⅛ of an inch. The drill can be carried whenever a man can carry 35 pounds, which is the weight of the heaviest single piece, and hence can be set up and operated in the most inaccessible places.

It will be evident that for prospecting work, when a certain territory is to be explored, this drill is particularly adapted.

Starting from a convenient and economical source of power, we can, if desirable, lay our wires along the surface of the ground, and in a very few hours can be operating our drill miles off. We can then reel up our wire and lay it again in an exactly opposite direction, and again be in operation at perhaps five or ten miles off in the course of a few hours more. In laying the wire a couple of horses yoked abreast and carrying a reel is all that is necessary. For operating at a distance of one mile in any direction the diameter of the wire necessary is but one-tenth of an inch and the total weight of the wire only 340 lbs.

The facility with which prospecting and also drilling in permanent works such as mines, can be done with this drill will no doubt lead to its rapid and general use.

There is every reason to expect that with the electric diamond drill the speed of the rotation of the drill can be very greatly increased with consequent increase in the rate of drilling, which is of the greatest importance.

The Edison General Electric Company have a third kind of drill which is a rotary high-speed drill, having a solid steel bit, and this drill is used for drilling coal and similar comparatively soft materials, and also for drilling metals where it will have an extensive use in the construction of steel ships and bridges and similar works where the drill has to be taken to the work rather than the reverse.

With the three drills which I have described, the Edison Company is now able to do any class of drilling desired, and these drills are likely to play an important part in the future of mining engineering.

The electric mine locomotive and the hoists, pumps, ventilating fans, crushers, stamps, and so forth,operated by electricity are instances of the application of electricity to mining which have already proved themselves entirely successful. The under-cutting of coal by electricity is an important field in which the Edison Company has made great strides, the machines being of two entirely distinct types,which become necessary in order to properly comply with the conditions met with in practice in different mines.

The electric refining of metals, especially of copper, is an extremely interesting subject to the mining engineer. The Edison Company have established the majority of the plants of this nature in the United States, and I need only say that the results are highly economical and most satisfactory in every way.

The electrical transmission and conversion of energy at great distances is destined to come up in nearly every mining problem in the future. Mines are usually in a mountainous country and it is seldom that a water power cannot be found within a few miles of a mine. The mining engineer in the immediate future will develop this water power, convert its energy into electric energy in which shape he will transmit it to the distant mine, when it will be again converted into the various forms of energy which he may have occasion to require.

Among the applications will be the following:

1. The lighting of the mines and the buildings and grounds by arc and incandescent lamps.
2. The operation of any machinery in the mill, such as crushers, stamps, and so forth.
3. The operation of the drills.
4. The operation of the hoists.
5. The operation of the pumps.
6. The operation of an electric tramway in the mine.
7. The operation of ventilating fans.
8. The heating of the buildings when fuel is scarce.
9. The refining of copper and recovery of gold and silver in certain cases.
10. The concentration of magnetic ores in certain cases, such as iron, nickel, and so forth.

In order to give you a commercial idea of a plant such as is likely to be used in mining operation in the immediate future I will suppose a case and give you an estimate of the first cost and operating expenses of such a plant. Let us suppose that we have a mine where we have to operate the following devices:

360 incandescent lamps of 16 candle power each,
10 arc lights,
1 hoist requiring 30 horse power,
1 pump requiring 20 horse power.
6 percussion drills for drilling 1½ inch holes at the rate of three inches per minute,
2 rotary diamond drills, 1¼ hole, ¾ core, rate two inches per minute,
1 mine locomotive, 10 horse power,
Milling machinery requiring 30 horse power,
Heating requiring 10 horse power.

The total power required for the above will be 180 horse power delivered by the main motors. Suppose that at a distance of three miles there is a good water power which can be developed and equipped with water wheels to produce 300 horse power by an expenditure of $15,000. In considering transmission of the power by electricity we must first determine what loss we shall sustain in transmission and then we must determine what electrical pressure we will operate with.

In designing such a plant there are certain fixed laws governing the conditions of highest economy and minimum first cost, and some years ago I investigated these questions and deduced formulæ expressing these laws.

These formulæ are given in tabular form in the accompanying Resume Fig. 1. I have also expressed the laws governing the conditions of minimum initial cost graphically in the diagram Fig. 2.

It may be interesting to note here in passing, a fact which you will observe by examining the formulæ given, namely : If we pay proper attention to the laws governing the highest efficiency and the least first cost, the cost of the conductors for the plant will be independent of distance and will depend solely upon the percentage of initial E. M. F. and the distance. Thus under practical conditions to-day, if we are to operate with 2,000 volts E. M. F. at a distance of 5 miles the minimum first cost would be realized when we operate with a loss of 20 per cent. in conductors. The cost of copper (at 20c. per bbl.) for each horse power delivered at the motor brushes under these conditions would be $7.47. This simple but invariable law which is embodied in the formulæ given herewith, you will find of great assistance to you in considering questions of electrical transmission.

You will also notice that the formulæ show that, for any given per centage of loss, the electrical pressure to be employed will vary directly with the distance. Thus, for 20 per cent. loss, the cost of copper being $11.20 per horse power delivered at motor brushes, the E. M. F. necessary for transmission of 16,000 feet will be 1,500 volts ; at 32,000 feet we should use 3,000 volts, and at 8,000 feet 750 volts.

In order to secure the 160 horse power necessary at our various devices in and about the mine, we must deliver 200 horse power to our main motor in the form of electric energy in the conductor at the brushes of the motor. With 25 per cent. loss in conductors this will

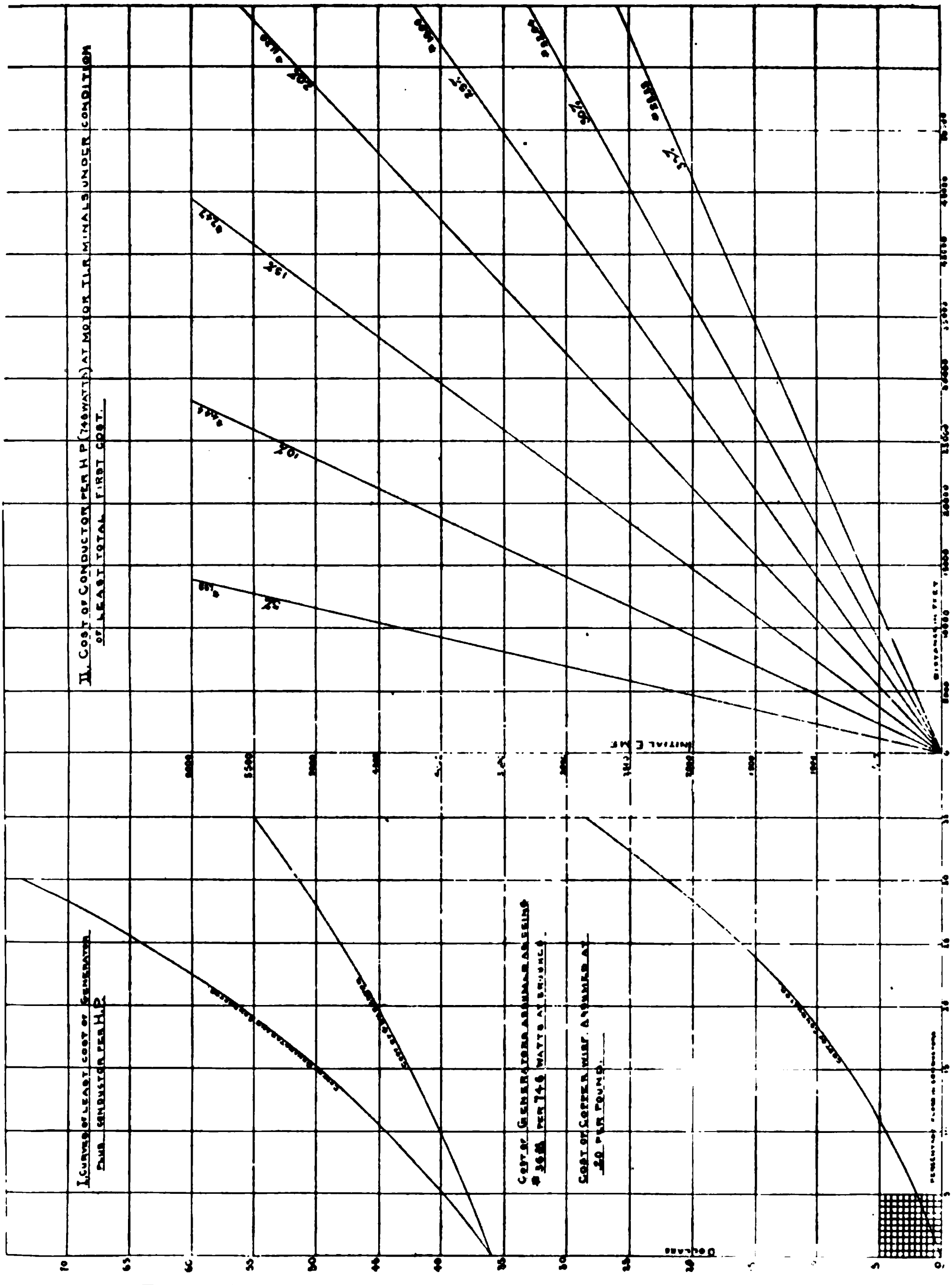

FIG 2.—Curves showing least total first cost of generators and conductors.

mean 266 horse power at the generator brushes, or 300 horse power delivered by the water wheels.

For the sake of reliability and economy we will use two generators instead of one, each being of 133 horse power. At the mine there will be two main motors of 90 horse power each, wound for 900 volts and 83 amperes, producing a total of 180 horse power, which will drive the drill generator of 17 horse power and a generator of 250 volts and 300 amperes for operating the incandescent lamps, the arc lamps, the locomotive, the hoist, the pump, the diamond drills and the heating. The main motors will also supply the milling machinery with the necessary 30 horse power.

By formulæ on Fig. 1, we find that to transmit 180 horse power three miles with 25 per cent. loss and an initial pressure of 1,200 volts, there will be required a wire having a circular millage of 190,000 circular mills; this is having a diameter of 436 thousandths of an inch or a little less than half an inch.

We find that by other formulæ on Fig. 1 that the copper will weigh 20,000 lbs. and will cost $4,000, which results check each other and prove the accuracy of the calculation.

We are now able to make an estimate for the total plant, as follows:

Estimate of cost of plant for transmitting 180 horse power a distance of 3 miles with a loss of 25 per cent. in conductors, the plant to comprise the apparatus as specified:

Developing original water-power and installing water wheels of 300 horse power	$15,000
2 Generators 100 KW. each (1,200 v—83 amperes each) at $36 per KW	7,200
2 Motors, 75 KW. each (900 v—83 amperes), at $36 per KW	5,400
Copper, 32,000 feet, No. 000 B. W. G.	4,000
16-Drill Generator	2,000
1 Generator of 250 v 300 amperes, 75 KW. at $36.	2,700
6 Electric Percussion Drills	3,300
2 Electric Diamond Drills	1,100
360 Incandescent Lamps and Appliances	360
10 Arc Lamps	220
1 30 KW. Hoist	2,255
1 20 KW. Pump	1,595
1 10 KW. Locomotive	1,815
Heaters, 10 KW	600
Conductors for all secondary transmissions	1,000
Labor of Installation	3,000
Poles	455
Freight, cartage and sundry expenses	1,000
Total	$53,000

The operating expenses of such a plant will be those mainly due to the wages of two men, one at the water-power and one at the mine.

A fair allowance for depreciation and repairs will be 5 per cent. per annum of the first cost.

The operating expenses will therefore be about as follows :

1 First Operator	$900 per year.
1 Second Operator	600 "
Depreciation and Repairs, 5 per cent. on $53,000	2,650
Sundry incidental expenses	250
	$4,400

The production of the same power by steam, when coal is $2 per ton and labor such that engineer's wages are $2.00 per day, would be not less than double this amount, and in many instances where water and fuel suitable for the generation of steam are difficult to obtain, such a plant would represent a saving of its entire first cost every year.

DISTRICT OFFICES:

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THE SELECTION OF REAL ESTATE.

This is one of the most important matters with which the Local Company has to deal, and many details in connection therewith must be carefully considered before the final decision is made, as *a mistake* in this matter at the outset, *directly affects* the net *earning capacity* of the station during the entire term of its existence.

We know of one station where the selection was so unfortunate that a new property has been purchased 1,200 feet nearer the centre of distribution, the entire station removed and rebuilt, and a new system of feeders put up, all to overcome the disadvantage under which the station existed in its old location; and of another which will probably soon be changed at a cost of upwards of $100,000.

Primarily the cost of a lot, added to the cost of copper required in the feeders (to carry the current to the mains), determines the actual value of any givenpiece of property.

The geographical centre is very often not the centre of illumination.

When you get away from this latter centre, the cost of copper increases as the square of the electrical distance, and a lot within 500 feet of the centre may be cheap at an apparently high price, while another, a few hundred feet away, be costly at a very much less price.

In selecting a lot, give careful consideration to the following important matters, which, as they affect the actual operating expenses as long as the station exists, are of vital importance.

WATER FACILITIES.

If possible, get near a stream of good pure water, or in a location where a reliable well of large capacity can be put down for a reasonable sum.

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The cost of water (taken from city mains) will average as high as from one and one-half to four per cent. of the total monthly operating expenses of a station.

A good driven or gang well will usually furnish a sufficient water supply for all the boilers in a station. If a surplus supply is obtainable in sufficient quantity, it can be profitably utilized for purposes of condensation, and thus save at least 15 per cent.

COAL TRANSPORTATION.

It is desirable to have the lot so located that the cartage of coal is avoided. If a railroad side track can be laid to the lot, this cost may be saved. This will often save from $10 to $30 per month in the expense of operating a station.

SOIL.

Solid ground is absolutely necessary, so that substantial foundations may be erected and vibration avoided.

Be sure to avoid swampy or mucky soils, or filled-in ground. The following are desirable, in the order mentioned: **hard gravel, solid earth, rock.**

A corner lot, or one with an entrance to the side or rear, should always be obtained.

By reference to the plans it will be seen that stations of from 900 lights to 1,600 lights capacity can be erected and conveniently arranged on a lot 30 feet by 100 feet; but ample facilities for the delivery of coal and the removal of ashes should be provided.

For stations of larger capacity a lot 50 feet by 100 feet should be selected.

On a lot 50 feet by 100 feet can be arranged stations of from 1,600 to 10,000 lights capacity.

If any doubt exists as to which is the most desirable property for the purpose, we would suggest that a map be sent us showing the location of several available plots, with a description of their advantages and prices, and, with a canvass of the location of lights, after looking over the canvass of the district, we can readily determine which is the best selection.

STATION BUILDING.

This should be of the most substantial character. Nothing less durable than a well-constructed brick building should be erected.

It is not economy to put up a cheap frame building to effect a saving in *first cost.*

A building of this kind can only last a very few years under the most favorable conditions, and is always liable to destruction by fire.

PREPARATION OF MAP AND CANVASS OF TOWN.

An accurate city or town map should be secured, showing all the blocks, streets and alleys of the district which it is proposed to traverse.

This map should be accurately copied on tracing cloth on a **scale of 100 feet to the inch.**

The names of all the streets and alleys should be distinctly written in their proper places.

When this is done the face of each block should be divided off into sections of one hundred feet front, and the fractional part thereof as the blocks may measure.

It is important that the map be accurately made to the scale we have stated, and that great care be exercised in the correctness of details.

If either or both sides of the street are obstructed by trees it must be so indicated on the map.

The character of the soil—rock, sand, gravel or earth—should be noted for each street; also the kind of pavement.

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If any restrictions exist, or are likely to appear against the right of way for underground conductors or overhead system *in any particular streets,* a note must be made of it on the map; in fact the right of way should be secured, and endorsed on the map. If an overhead system is used, it is very desirable to erect it in the alleys and side streets, as far as possible.

CANVASSING.

A personal visit should be made in each building, between the hours of 5 and 9 P. M., and the AVERAGE *number of lamps in use at any one time* carefully noted; that is to say, buildings whose occupants will be desirable customers.

The records should be made in a note book, so that they may be easily transferred to the map without error.

The canvass having been completed, the number of lamps per 100 feet front on each side of each street should be noted on the map.

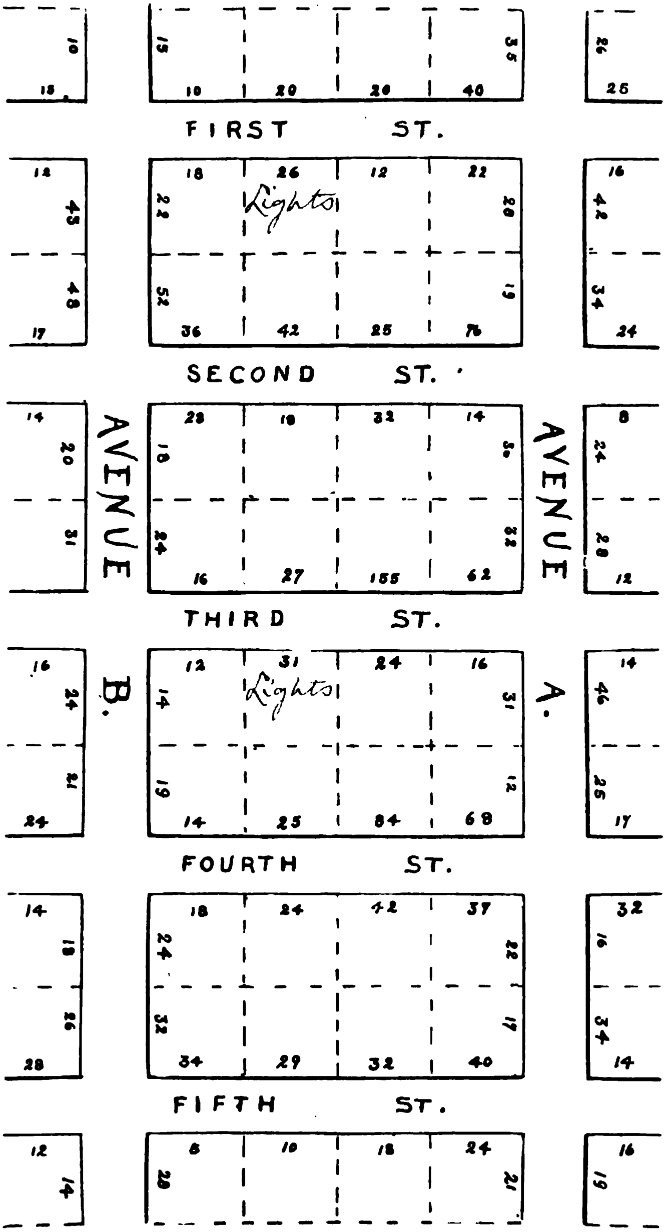
This is important work, but can be as well done by local people as by ourselves, and at a small fraction of the cost.

The map and canvass having been prepared as above directed, it should be endorsed and approved by the officers of the Company and the Board of Directors, and the map is then ready to forward to us for the electrical determination, and it then becomes a basis for *accurate* estimates of all costs.

All other factors being in our possession there can no longer be any uncertainty in the matter of determining either the investment or the cost of operating.

The map, with full information and instructions, should be addressed to

The following illustration shows section of a completed map:



Figures indicate number
of lights necessary

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